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VALUATION OF WATER WORKS FOR MUNICIPAL PURCHASE[1]

By E. E. BANKSON[2]

The purpose of this discussion is to direct your attention towards certain features of four recent purchase cases at Wheeling, W. Va., and one at Pikeville, Ky., rather than to attempt a conclusive discussion of the subject at hand.

The conditions surrounding these cases were rather unique in that the utilities had no legal rights, whereby the law could be called into play as an indicator of the fair value. This condition placed the evaluating engineers in the position of judges, with the duty of finding the fair value. It made it incumbent upon the engineers to give complete consideration to both sides of the case, rather than to leave some mooted questions to the other side of the controversy with the thought that the court or commission would have the deciding vote, whereby justice would, in the end, be obtained.

The unique condition was that a public utility does not have an exclusive franchise in West Virginia, and, for the case in Kentucky, the franchise had expired, which means that in either of these cases the city had the right in law and in fact to parallel the mains of the utility, if they finally chose so to do.

The engineers for the city proceeded to value the property and to recommend a purchase price therefor in each of these cases (except one) which will be discussed more or less as to certain details. Before

[1] Presented before the Central States Section meeting, December 6, 1924.

[2] Consulting Engineer, with J. N. Chester Engineers, Pittsburgh, Pa.

doing so, however, let us briefly examine the law and the practice in this connection as a means of justifying the final value found in each case, remembering at the outset that the United States Court decisions recognize only "present fair value," without usually specifying how said fair value is to be determined.

Turning to the "Public Utilities Digest" for the year 1923, as possibility representing present practice, under the heading "Ascertainment of Value for Purpose of Sale" we find four references as follows:

118. The value which might be determined for condemnation purposes does not represent the reasonable price for which two utilities should be authorized to transfer property to each other when duplication exists in the systems, which, upon transfer, will result in the taking down of certain lines and reducing them to a salvage value. Re Pacific Gas and Electric Co. (Cal.) P. U. R. 1923C, 535.

119. The price at which a Commission authorized the purchase and sale of electric property was represented by the historical cost of the property less the reasonable depreciation accrued by each party in the normal operation of its business. Re Pacific Gas and Electric Co. (Cal.) P. U. R. 1923C, 535.

120. The valuation of property for the purpose of sale should be made in the same manner as if it were made for the rate-making purposes, although this value may not necessarily be used as a basis for fixing rates in the future. Re Princeton Teleph. Co. (Ind.) P. U. R. 1923A, 620.

121. Some consideration must be given to current prices in fixing the fair value of utility property for the purpose of ascertaining a proper sale price and a proper basis for securities. Re Watts Engineering Co. (Mo.) P. U. R. 1923E, 459.

In order to clarify the meaning of paragraph 118 above quoted, we may do so by reviewing the case of a value fixed by the California Commission for condemnation purposes, which may be found in the Public Utility Reports 1921-C, Page 1, where it is stated that the Commission had before it six engineering estimates as follows:

1. The historical reproduction cost.
2. The reproduction cost new on the basis of average prices for the preceding five years.
3. The reproduction cost new on the basis of prices as of May 2, 1918, the date of the filing of the application.
4. The reproduction cost less depreciation based on the historical reproduction cost.
5. The reproduction cost less depreciation based on the five-year period reproduction cost.
6. The reproduction cost less depreciation based on the date of valuation reproduction cost.

After handing down a decision based upon the evidence, as indicated above, the power company made petition for rehearing at which time the Commission ordered a joint report to be prepared by engineers of the company and engineers of the commission, with instructions that this joint report be based upon "market unit prices" for the year ending May 2, 1918, specifying that the average price for materials, based on actual sale prices referable to the case at hand, be used as far as possible. The final value fixed was based largely upon reproduction cost estimate as of the date specified in the amount of $49,177, including $2,784 as development costs, which may be considered as akin to going value.

Paragraph 118 above quoted seems to be a justification of paragraph 119, wherein present day construction costs seem to have played no part, and where the figures serving as the basis for the decision appear as follows:

Properties to be transferred to Western States Gas and Electric Co.:	
Historical cost less depreciation, April 1, 1921	$92,015
Additions and betterments to June 1, 1922	12,206
Total	$104,221
Properties to be transferred to Pacific Gas and Electric Co.:	
Historical cost less depreciation, April 1, 1921	$37,977
Additions and betterments to June 1, 1922	4,718
Total	$42,695

Under the heading "Ascertainment of Value for Municipal Purchase" in the Public Utilities Digest for 1923, we find reference to two cases as follows:

1. The purchase of the water works plant by the City of Stockton, Calif., where the reproduction cost new less depreciation, as developed by the Commission's Engineers, amounted to $1,447, 517, which the Commission admitted should be slightly increased, and finally fixed a fair value of $1,400,000.

2. The Water, Light and Power Company of Milton, Wisconsin, where the Commission considered appraisals on a basis of five-year average and on the basis of ten-year average, covering the ten years preceding the date of appraisal, although the reference does not show the final fair value fixed.

The Pennsylvania law specifies the method of evaluation for municipal purchase as follows:

It shall be lawful . . . . for the city or district . . . . to become the owners of said works . . . . by paying therefor the net cost of erection and maintaining the same, with interest thereon at the rate of 10 per centum per annum, deducting from said interest all dividends theretofore declared.

The opinion of the Courts, with respect to rate cases, has been more often stated in the last two years in favor of reproduction cost new less depreciation on the basis of actual present day prices. For instance, in the New York Telephone case, the United States District Court said:

While no one element is exclusive of all others, reproduction cost less depreciation is the dominant element in rate base ascertainment . . . . .

In the Bangor Water Company rate case, the Superior Court of Pennsylvania quoted previous opinions in other cases, as follows:

In determining the present fair value of a public utility property, the reproduction cost new, at fair average and present prices, less accrued depreciation, is of great use and should properly be considered as to plant and structures . . . . though it is not necessarily the same as the reasonable present value of such property . . . . and it is the latter on which the reasonable rate of return is to be based.

For a purchase case in West Virginia, a private purchaser could not safely pay more for a water works plant than the value which would be permitted by the West Virginia Commission for rate-making purposes, unless, however, an appeal was made to the Courts, and to answer the foregoing question, we should examine the practice of the West Virginia Commission as described in a statement, which was made shortly previous to the date of the valuation of these properties, as follows:

An effort is made to use an average of prices over a term of years that would cover the period, during which the major portion of the construction work was done. Book additions from such date to the time of valuation are always added with depreciation deducted. . . . . When a book value is ascertained by auditing the books, accrued depreciation is deducted from the capital account, which establishes the book value of the property.

Regardless of whether or not the foregoing method would determine a fair value, it surely is true that a private purchaser would be taking a long chance to pay more than such a figure for a public utility plant in West Virginia.

In considering all of the factors which might go to make up the fair value in those particular cases, it appeared to the engineers that a figure representing estimated absolute reproduction cost, less depreciation, of the portions of the plant which would be useful to the City of Wheeling, and expressed as "Estimated Worth to the City" would be pertinent and helpful in finally arriving at a fair value, and

the figure which we would recommend that the city incorporate in its offer to purchase the plant.

Tabulations are reproduced herewith, showing the summary of figures developed in the engineers' report, with respect to these properties. The figures dealing with pre-war prices and historical

TABLE 1

Warwood Water Works, Wheeling, W. Va., July 1st, 1922

Final summary

ITEM	ESTIMATED HISTORICAL COST		REPRODUCTION COST		ESTIMATED WORTH TO CITY	
	New	Depreciated	New	Depreciated	New	Depreciated
Water supply system	$ 7,425	$ 6,562	$10,321	$ 9,250		
Distribution system	36,440	31,232	58,833	50,582	$51,645	$43,383
Real estate improvement	180	142	280	220		
	44,045	37,936	69,434	60,052	51,645	43,383
Contingencies and engineering, 10 per cent	4,405	3,794	6,943	6,005	5,165	4,338
General administration, 2 per cent	881	559	1,389	1,201		
Total—construction	49,331	42,289	77,766	67,258	56,810	47,721
Organization cost, 2 per cent	881	881	1,389	1,389		
Real estate	1,200	1,200	2,500	2,500		
Interest lost during construction:						
1 per cent on construction	493	423	778	673	568	477
2 per cent on organization and real estate	42	42	78	78		
Total—exclusive of supplies, etc	$51,947	$44,835	$82,511	$71,898	$57,378	$48,198

The final figure recommended by the engineers and the price paid, $57,000

cost prices were included, not for any weight or influence which they might have in finding the fair value, but rather to serve as a measuring stick for the vendor, by which he might test the justice of the offer made by the city, and for the second purpose of satisfying the curiosity of the purchaser as giving some indication of what he

might have paid had he made this purchase under the condition of pre-war prices.

The summaries for all of the plants in the Wheeling cases are exclusive of going value or intangibles, while the worth to the city in the case of Pikeville, Ky., included an item for intangibles or going value.

TABLE 2

Loveland Water Works, Wheeling, W. Va., August 1st, 1922

Final summary

ITEM	ESTIMATED HISTORICAL COST		REPRODUCTION COST		ESTIMATED WORTH TO CITY	
	New	Depreciated	New	Depreciated	New	Depreciated.
Water supply system	$13,694	$12,759	$15,829	$14,763		
Distribution system	15,450	13,363	22,074	19,274	$17,656	$15,515
Total	29,144	26,122	37,903	34,037	17,656	15,515
Contingencies and engineering 10 per cent	2,914	2,612	3,790	3,404	1,766	1,552
General administration, 2 per cent	583	522	758	681		
Total—construction	32,611	29,256	42,451	38,122	19,422	17,067
Organization cost 2 per cent	583	583	758	758		
Real estate	3,200	3,200	3,200	3,200		
Interest lost during construction:						
1 per cent on construction	326	293	425	381	194	171
2 per cent organization and real estate	76	76	79	79		
Total—exclusive of supplies, etc.	$36,796	$33,408	$46,913	$42,540	$19,616	$17.238

The final figure recommended by the engineers and the price paid, $20,588.

Dealing more specifically with the figures designated "Estimated Worth to the City" we have the condition where the city is to provide a new pumping station and filtration plant, with the result that the old pumping stations, filtration plant, and reservoirs will be of no use or value to the city under the new operation. These items, therefore, have been excluded from the "Estimate of Worth," except

TABLE 3

Elm Grove Water Department, Wheeling Public Service Company, June 1, 1922

Final summary

ITEM	REPRODUCTION COST ESTIMATES				ESTIMATED WORTH TO CITY	
	Pre-war prices		Present prices		Present prices	
	New	Depreciated	New	Depreciated	New	Depreciated
Water supply system						
Patterson, Station and rising main	$38,533	$ 30,684	$ 58,418	$ 47,281		
Fulton Wells, Station and rising main	19,501	16,959	30,848	26,896		
Water distribution system						
Reservoirs and tanks	21,789	20,370	33,479	31,506	19,895	19,059
Street mains, services, etc.	107,432	80,544	186,973	140,805	203,393	133,130
Total	187,255	148,557	309,718	246,488	223,288	152,189
Engineering and contingencies, 10 per cent	18,726	14,856	30,972	24,649	22,329	15,219
General administration 2 per cent	3,745	2,971	6,194	4,930		
Total—construction	209,726	166,384	346,884	276,067	245,617	167,408
Organization cost 2 per cent	3,745	3,745	6,194	6,194		
Real estate, say	6,000	6,000	6,000	6,000	2,000	2,000
Interest lost during construction:						
3 per cent on construction	6,292	4,992	10,405	8,282	7,369	5,022
6 per cent organization and real estate	585	585	732	732	120	120
Total—exclusive of supplies	$226,348	$181,706	$370,215	$297,275	$255,106	$174,550

The final figure recommended by the engineers and the price paid, $200,405.

in one case where it was first intended that the city would make use of the reservoir in question.

With respect to street mains, in this "Estimate of Worth," it was recognized that certain small mains would prove inadequate for service under operation by the city, for the city would be obligated to provide fire protection throughout all parts of the city, which was not always the case with the private water company. It was recognized that those smaller mains would, in the majority, have to be replaced by larger lines capable of fire service delivery within a short time, and that in these cases, the "Worth to the City" would be represented by the "Present Worth" of interest and depreciation, on cost new, saved by the city until such time as said mains will probably be replaced, rather than to use the depreciated value of street mains.

TABLE 4

The Mountain Water Supply Company, Pikeville, Kentucky

	PLANT	
	New	Depreciated
On basis, historical cost (page 1)	$12,820	$10,814
On the basis of present construction costs (page 1)	28,447	24,121
On the basis, 5 years average construction costs (page 2)	26,737	23,518
On the basis, 10 years average construction costs (page 2)	22,822	19,300
On the basis of "Worth to City of Pikesville," (page 3)	29,045	25,433

The final figure recommended by the engineers and the price paid, $25,433.

In this study of "Estimated Worth," there was included the cost of cutting the present pavement wherever it would be necessary to cut that pavement in laying the mains of a new distribution system, if that were being planned, under present day conditions. In the complete reproduction cost new, under present prices, an estimate, for cutting pavements was included only so far as pavement has actually been cut by the private company, which is strictly in line with the law and the practice in this connection.

It was finally decided that the prices to be paid, or the offer which the city should make these various plants, should be based on the "Estimated Worth to the City," with the understanding that the

city would acquire title to only the portion of the plant which would become useful; the company retaining ownership of the remainder of the plant. It is, possibly, of more interest to observe the results of this decision rather than to study all the reasons therefor.

On careful consideration of these cases, it will be evident that where the private company had considerable investment in water supply equipment (not useful to the city) this stated formula for price would create a greater reduction below the figure of reproduction cost new today of the entire plant than in the case where there was a smaller investment in water supply plant and equipment, as distinguished from water distribution plant.

In the case of the first company discussed, we were given every assistance in taking the inventory and in developing the facts to obtain a fair historical cost estimate, the company actually donating the time of their engineer to assist the city's engineer in developing historical facts.

In the case of the second company, we again had full coöperation with respect to the inventory, and the books were thrown open to the engineers for any use they might wish to make of them.

In the case of the third company, full coöperation and assistance was given with respect to the inventory, but access to the books of the company was refused.

The case of the fourth company at Wheeling was entirely a case of bargaining and will be touched upon later.

In the Pikeville case, the company refused to give any assistance whatever with respect to the inventory, and refused access to the books.

After valuation reports had been made in each of these cases, and the offer of purchase had been made by the city, the company, in the first case, as described above, was entirely satisfied with the offer made by the city and the offer was accepted as of the same date on which it was made.

In the second case the company was not so well satisfied with the offer, for almost half of their investment was in water supply plant and equipment, and the other half in water distribution system, but the company finally accepted the offer on the same day of said offer, with the thought that they might be able to sell the water supply portion of their plant elsewhere, in which case they would realize a very fair price for the entire plant.

In the third instance, the company conducted an extended struggle

to realize a higher value than that recommended by the city's engineers, and it became necessary to go so far as to advertise for bids on cast iron pipe for paralleling the mains to the private water company. The water company finally accepted the city's offer on the day previous to the taking of bids for said cast iron pipe.

In the case of Pikeville, Ky., there was no consideration given to the offer as made by the city. The Company asked a price about three times the amount of said offer and gave public notice that the water would be turned off, and the plant shut down, unless the city consented to arbitration, which was refused by the city.

The water was turned off on schedule time, the city obtained an injunction forcing the company to continue service, the engineers prepared plans and specifications for a complete system to parallel the system of the private company, the call for bids was advertised, and it was not until after all bids were received and analyzed, by the engineers, that the water company finally accepted the offer as made by the city.

The fourth purchase case, at Wheeling, was entirely a bargain proposition, where a system that would appraise at, possibly, three to five thousand dollars, under present day construction costs, was purchased for $230. The revenue from the plant was not sufficient to meet operating expenses, and the company was glad to be relieved of the duties attached, on condition that the city assume the obligation of the last unpaid bill. This case offers a splendid example of a condition where appraised figures do not constitute the controlling factor.

In closing, I would not leave the impression with you for a moment that this formula could be used in every purchase case, and further I would not care to recommend it in any case until after I was thoroughly conversant with all the details of the situation. No formula should be followed blindly and nearly every case has its own peculiar features.

DISCUSSION

Leo Hudson:[3] Mr. Bankson has referred to the law of 1874, the law of Pennsylvania, and by the way he referred to it, it seems to be easy to purchase a plant under that act, that is for the actual value, plus ten per cent, less the dividends that have been paid.

[3] Consulting Engineer, Pittsburgh, Pa.

I was the engineer who represented the Borough of Russellville in the purchase of a plant, where we proceeded under the Act of 1874. The matter was actually reviewed by the Public Service Commission of Pennsylvania and in its very clear interpretation of that Act, by the same language, the company reached a figure of $312,000 and some of the most radical persons interested in the company, from the view point of the buyer, under the same language, reached a figure of $4000. Now, the Public Service Commission in its review did not agree to the $312,000, which was the contention of the company, and did not agree to the $12,000 which was the contention of Mr. Brown, the attorney who was representing the Borough, but fixed an amount of about $78,000. One of the Commissioners, Commissioner Reading, gave a dissenting opinion and stated that in his view the value of $12,000 was correct.

That problem was taken back to the Public Service Commission and the Commission heard the argument on it a second time and could not see any reason why it should change its original opinion and Commissioner Reading a second time issued a dissenting opinion, We purchased the plant for the amount stated by the Commission, $78,000, but there were three figures, $312,000, $78,000 and $12,000. As a matter of fact when the Commission rendered its decision it paid absolutely no attention to the Act under which we were making the purchase.

The reason for the difference of opinion was this: the company had been making expenditures every year. The promoter of the company was in the penitentiary. He was then in the penitentiary, but I think he is out now. They declared no dividends. Therefore, by taking what money was put into the plant and adding ten per cent, as they did not declared any dividends, the attorney for the company reached the high figure. They did, however, call a meeting of the Board of Directors and declared what they called a stock dividend in lieu of past dividends, not declared. The promoter stole the greatest part of these securities and that was why he was at that time in an unhappy position. I just want to point this out to show you how that Act can be abused and why in Pennsylvania we do not look upon it as a reasonable method of trying to arrive at the purchase price of properties.

I think Mr. Bankson left the impression that any water company organized and chartered under the Act of 1874 was subject to purchase under that Act against its will. My impression is, although I

may be wrong, that there are no Acts in Pennsylvania by which a company can be forced to sell its property unless it wants to.

There was another Act, I think it was of 1907, or 1897, somewhere along there, which the Courts have ruled is a parallel Act to the Act of 1874 of Pennsylvania. That is the Act by which a company can be purchased, if they are willing, that is, if there is a willing buyer and a willing seller. The company appoints an engineer. The Court always listens to the recommendation of the purhcaser. The Court appoints three engineers. It works out in practice so that the company appoints an engineer and the Borough appoints an engineer and the two agree on a third engineer. These three engineers give the Court an opinion as to the value of the property and the Court may accept it or it can turn it down and get other engineers. It may offer a price to the buyer, and the owner has a right to accept or reject it. In case he rejects it, the municipality has the right to build a plant and parallel the lines, if the company refuses to abide by the decision of the Court. But that does not force the company to sell. It just forces the company to get a figure that it can accept or in the case of its rejection the municipality has the right to parallel the lines. Even after that is done, you have to appear before the Public Service Commission to get a certificate of public convenience to do that. The Public Service Commission of Pennsylvania—I am not authorized to speak for them at all, but I am willing to offer a guarantee—will never find public convenience to warrant parallel lines. Therefore, we have no Act which can force a company to sell, if it does not want to. You might say that, according to the Act of 1907, they have the right of paralleling, but they cannot, as a matter of fact, because the Public Service Commission will not let them do it.

When you speak of depreciation, to what kind of depreciation do you refer?

In a small case that we had, under the Act of 1907, we had a great deal of discussion about depreciation. I think that is perhaps the most important phase of a purchase valuation.

It does not seem to me that a valuation for rate purposes and one for purchase purposes are in the same category at all. It seems to me that it should be depreciated on the straight line method.

E. E. Bankson:[2] I think that depreciation, whatever method you use, if you use a method, should be as nearly consistent with the actual facts as you can make it. In these cases we ought to consider,

therefore, the sinking fund and the straight line depreciation. If you have a case where straight line depreciation seems to be the nearest indication of actual conditions, you should use it, because it comes nearest to the actual facts. If you had a case where sinking fund depreciation would be more satisfactory, I would be inclined to use that. I should certainly study it. There have been two or three decisions by our courts recently and I think it is in the Pacific Water Company case in Los Angeles where the Courts said that the proper method of depreciation was observed depreciation.

Leo Hudson:[3] Suppose you had a distributing system with 42 miles of pipe lines. You cannot observe in such an instance.

E. E. Bankson:[2] It is a hard job.

C. F. Drake:[4] You would appreciate the fact that your distributing system was going down hill.

E. E. Bankson:[2] I will just interrupt here to say that we cut several samples out of the pipe lines. We always take the position that we will not buy a pig in a bag. If it is a rate case, it is not very important, for several reasons.

In two or three recent cases our attention has been directed to the fact that the Courts seek observed depreciation. I have had occasion to go through a little law in times gone by. I wanted to familiarize myself with it a little more, especially if they state these new things, and I found that it was forty years ago that the Courts said that you must use observed depreciation. In other words, get as near to the actual facts as you can. If you cannot get that, do the next best thing, whatever it is.

Philip Burgess:[5] I think that is the very thing that we must appreciate, that a property has one value. I think that is a fundamental thought that Mr. Bankson has. I think that Mr. Hudson has the other thought, that there may be two values. How you arrive at that value is the important thing. The method you may use, consequently, in getting at the cost of a thing is one matter. The

[4] Division Superintendent, Pittsburgh Filtration Plant, Aspinwall, Pa.

[5] Consulting Engineer, Columbus, O.

manner of depreciation is another important thing. But the fact is this, that whatever the method of arriving at depreciation, either by sinking fund or straight line procedures, as I understand it, and as the Courts, I think, have expressed themselves, you are endeavoring to arrive at a fact, namely the depreciation of the property. The sinking fund is one method and the advocates of that method conceive the idea that the depreciation is not by the straight line, but that the property depreciates more rapidly as a new property and more slowly as an old property.

On the other hand, the straight line advocates conceive a uniform depreciation throughout the life of the property. A fundamental fact that has not been mentioned in rate cases is that you take the sinking fund and you arrive at a higher depreciation not affecting the gross annual income of the property. If you take the straight line, it gives a higher aggregate rate of depreciation, and a higher annual depreciation, but, if you use the straight line, the owners cannot take as much out of the property, because they have to set aside a larger depreciation reserve. They cannot use that as a dividend. With the sinking fund depreciation they get the same return, but they can take out of the property more money. That is a big difference.

I had a very interesting case before the Ohio Commission recently, where I represented the company. We used the straight line method because the Ohio Commission always used that method. As I saw it the state's engineers were not fair in their estimated lives and they arrived at a depreciation of 50 per cent on cast iron pipe. We cut out of the distribution system certain sections of pipe and brought them before the Commission. We did not do anything but clean them up, and we had a piece of new pipe, which had been lying around the ground for about ten years and they could not tell which was the new. Yet they had the pipe itself depreciated 50 per cent. The fact is that the pipe had not depreciated 50 per cent. The mere fact that they could not tell which was the old and which was the new shows it is the observed depreciation which should govern. You must determine what the actual condition of the property is. Where it is concealed in the ground, you must consider what is the condition of the property and what is the history of other properties. Take, for instance, the possible life of the property, of the cast iron pipe, as fifty, seventy-five or one hundred years. Take that and assume a certain useful life of the cast iron pipe and the property will have more than any value that you would determine in any other way of

valuing the property. If you take the sinking fund method, you will get one answer in arriving at your accrued depreciation and with the straight line another, but after all neither may be correct.

J. M. RICE:[6] I would like to ask Mr. Bankson a few questions, in regard to how he figures certain elements of value in these cases. A question of purchasing a distribution system: As I understand it, that was based upon what the value of that system would be compared with the price of a competitive system. In other words, what the lines are worth to the city as compared with what it would be if they put in the lines themselves.

E. E. BANKSON:[2] What it would cost them to put in a similar plant.

J. M. RICE:[6] Do you take into consideration a similar service, connections to the similar service? In other words, if the city parallelled the lines, would the consumers have their choice of taking water from the company or from the municipality. In order to take water from a municipality, they would have to make connections and somebody would have to bear that cost. Was that taken into consideration?

E. E. BANKSON:[2] Yes, it was. Consistent with the particular case.

J. M. RICE:[6] Do you also take into consideration that there would be a period of transition, you might say, during which the city would be losing revenue while people were changing over from the company lines to the city lines? Mr. Hudson can tell us something about that, because he was engineer in a case where that actually occurred. Do you take that factor of loss to the city into consideration?

E. E. BANKSON:[2] You know, the competitive going value is based on that very condition.

J. M. RICE:[6] That is why it comes up here. I want to know what you do.

[6] Consulting Engineer, Pittsburgh, Pa.

E. E. BANKSON:[2] We allowed going value in these various cases. I do hope that Mr. Hudson is not relying on this. He may get some bad advice.

LEO HUDSON:[3] I will take the responsibility.

J. M. RICE:[6] I understand you figured it on a comparative plant value.

E. E. BANKSON:[2] No, I will not say that I tie myself to any method in computing going values, but I do say that the method of computing going values covers the very thing you asked, since I included going value.

J. M. RICE:[6] In other words, you did give these two differences—you made an estimate of what those two factors mean and while you might not have accepted your estimate, you used it as a measure in arriving at the final figure to give to the company.

E. E. BANKSON:[2] Yes, the final price, which estimated a fair value of the property, included all of the facts.

UTILIZING THE STREAMS OF INDIANA[1]

By Richard Lieber[2]

The utilization of the water resources of our country has been a frequent topic of discussions relating to the conservation of the natural wealth of the land. Each enthusiast views the question with reference to his particular interest. The water power engineer sees in the stream stored up energy which he seeks to capture and convert into electrical power for lighting our cities and operating their mills. Municipal officials and owners of industrial plants see a source of water supply to serve to the public or to be utilized in manufacturing processes. The recreationist, whose nose is not held quite so close to the grindstone, and who looks upon this life as something more than dividends and profits paid in dollars and cents, sees an opportunity for enjoying a little of the "out of doors," for himself and his fellowmen. The sportsman and the commercial fisherman has visions of public harvest fields for their pleasure or financial profit.

The successful man, or state, or nation is one, however, who utilizes all of the resources to the best profit, whether it be in the efficient operation of mills and power plants, the enjoyment of the woods and streams for pleasure and recreation, or the harvest of health or more material substance from the lakes and water courses. How then can we more profitably utilize these resources so that in furthering their development in one direction we do not limit the rights of others of our citizens whose pleasures extend in another direction? Certainly there must be some middle ground which will permit a water course to be developed for power or transportation, to be utilized for draining our agricultural lands, to provide a water supply for the city or the factory and at the same time not trample upon the public rights of the sportsman, and the lover of outdoor life for legitimate recreation. This is the stand taken by the Department of Conservation of the State of Indiana and it is directing its efforts and resources to permit the fullest development and utilization of the waters of the state.

The rôle of water transportation in the settlement and early develop-

[1]Presented before the Indiana Section meeting, January 22, 1925.

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ment of the state from the coming of the early Jesuit fathers and the "voyageurs" in their canoes, through the flat boat days when bacon and maple sugar were freighted down our small rivers to the Ohio and the Mississippi trade centers of the South, to the ill-owned "canal fever" of the early forties, demonstrated the complexity and the rapidly changing character of even our early economic life and showed that, for a time at least, the "iron horse" had gained the upper hand.

What shall the future tell? Will speed give way to economy and result in a more complete development of our river systems as carriers of heavy freight? Will our lake ports at Whiting, East Chicago, Hammond, Gary and Michigan City radiate canals to the south and east permitting greater industrial development of cities not now on the lake front by bringing to their doors the ores from the north and the coal from the east and west? Or shall we send a line of barges across the northern end of the state to distribute our manufactured articles and raw materials to the industrial centers on Lake Erie? Will there be a Y shaped canal connecting Lakes Erie and Michigan with the Ohio River?

However visionary such a picture may be, we cannot permit ourselves to overlook the opportunity now at hand. The hauling of freight, especially fuel, is constantly placing a heavier burden on our present transportation systems and emphasizes the necessity that we utilize to the utmost forms of power available locally.

From a compilation made of the water power developments of the state by the United States Geological Survey, we find that 56,076 rated horse power have been installed. This compilation was made of developments of 100 horse power or more. The present rated capacity of the steam super-power plant near Terre Haute is 53,600 h.p. or only 2500 h.p. less than the rated horse power of all the water power developments mentioned above. The largest development is at Mishawaka on the St. Joseph River. Those on the Tippecanoe near Monticello are next in size.

Several surveys of the total water power available in Indiana have been made by the United States government agencies. One figure gives the water power that could be developed, without storage, as 118,000 horse power. If this figure be true then a little less than half of the available water power has been developed. In addition to the above estimated developments which are commercial in value we have smaller streams and brooks for very localized use.

While most of Indiana's streams are not primarily suited to the development of cheap power due to the high farming value of the lands lying along the banks, the demand for power in isolated communities far from the super-power plants of the coal fields will eventually lead to the development of all water powers of any size.

To my mind many of our villages and towns may take a lesson from the town of Kingsbury near LaPorte. Here a small hydro-electric plant of a few horse power has been installed and the current furnished by this plant lights the streets of the town as well as many of the homes. Many farms of the state have brooks and small streams flowing through them and these can be developed economically and the power obtained by such development used to light the farm buildings and to lessen the drudgery of washing, churning, etc. For the use of the farmer these brook and stream developments will be valuable in that their use will do away with the gasoline or kerosene driven generator and provide a small plant whose upkeep is practically limited to cost of lubrication and new generator brushes.

In connection with water power development the Division of Engineering of the Department of Conservation is engaged in a stream gaging program which will be valuable in a few years time. Primarily this program was inaugurated as a means of securing stream flow and run-off to be used in drainage and flood protection works.

To date 20 gaging stations have been established on the principal rivers of the state and 125 meterings have been made. A few stations have been established for two years, the remainder, a shorter time. If time and personnel are available for this work during the coming summer we intend to publish the results from a number of stations next fall. Already a number of promoters and officials of power companies have made use of the unpublished data in our files and there seems to be a growing demand for it even in the present stage of unchecked condition.

Such stream flow data are primarily in demand by those in charge of the design of drainage and flood protection systems. It is the basis for run-off estimates, flood height estimates, size of drains and bridge opening data.

Our Division of Engineering carries on this work in addition to its regular work of review of drainage projects, a state drainage survey, an extensive ground water elevation investigation in the Kankakee Valley and as a service division for engineering design and construction of other divisions of the Department. The original plan for the

stream gaging program called for 30 gages and this is all that would be needed for drainage and flood protection data. As these particular data are all that the Division of Engineering is authorized by statute to secure and compile, it is obvious that many gaging stations advantageous to that portion of the public interested in the development of water power, cannot be installed. Authorization to continue this work, together with an additional fund to care for the added expense of 30 or 40 more stations is needed before we can measure the flow of all the streams of the state that have suitable power sites along their course.

Up to this point we have treated of the question of utilizing the streams with reference to the economic and industrial development of our state. There is another phase in our development which cannot be measured in dollars and cents, in kilowatts of electrical energy developed or tons of coal saved. It is that intangible question of public health, particularly the rôle played by recreation and outdoor life.

Our population is increasing and our agriculturists are continually placing more land into active cultivation. The question of obtaining food is after all of foremost importance. But care must be used not to upset natural balances and come out at the short end of the horn after all. Woodlets are being cut over and streams denuded of the trees along their banks. Tiling of the fields and the construction of dredged ditches in the channels of small streams while undoubtedly increasing the productiveness of some of our soils during favorable seasons is slowly, but certainly, depleting the state of its fishing and its recreation grounds, whether used for a day's outing or a week's camp in the open. What can we do to maintain for our citizens an opportunity to continue to enjoy outdoor life without compelling them to travel to the less extensively developed states to the north and northwest?

The Department of Conservation cannot, and is not, seeking to restrict the agricultural development of the farms of the state, but it does see an opportunity in some measure, to return to the people of the state a substitute for what has been taken away in the form of open streams and natural recreation grounds by creating and fostering a sentiment for public parks, forest reserves and fishing grounds along some of the rivers and lakes not yet vitally disturbed by our highly developed agriculture and industry.

To this end it has been possible to set aside a few places of natural

beauty such as Turkey Run Park, McCormick's Creek Park, Clifty Falls and the Kankakee Game Refuge with a very promising prospect of the addition of other areas in the lake regions of the northern part of the state.

Although sentiment may largely enter into the question of what is enjoyable recreations, and I believe it should rightly do so, yet for other reasons the use of these tracts of limited area are undoubtedly justified by the return which they give to the people in enjoyment and health and the stimulant to renewed energies given through a few days vacation under such surroundings. This is one means of utilizing the waters of the state and altogether probably as profitable a one as their use for any financial gain.

THE BOONE WATER SUPPLY[1]

By C. L. Ehrhart[2]

Previous to 1912, the city water works of Boone was very much of a struggling institution, the main struggle being for an adequate supply of water. Deep wells had been tried, two being sunk to a depth of 3000 feet or more with the hope of securing an artesian flow, but failing to secure such flow it was necessary to pump these wells with a deep well outfit. This proved to be an expensive method and at its best only a temporary relief, for the wells gradually failed and had to be abandoned. Shallow wells were next tried, several being sunk about $\frac{3}{4}$ mile from the pumping station. The water was raised to the surface by an air lift and flowed to the city reservoir by gravity. For a few years this supply proved ample. It happened, however, that the Chicago and Northwestern Railway shops were a few hundred feet from the city's wells, and the railroad company was pumping its water supply from wells, tapping the same source as the city's wells. With an increasing demand on the part of both the railroad and the city, both sources of supply proved inadequate. The situation reached such a stage that at times the city did not have 100,000 gallons of water in reserve and it became necessary for the railroad to haul water into Boone in tank cars. Naturally, the Northwestern could not afford do do this and it became a question of securing an adequate supply or closing down the shops.

After a series of conferences between the city and the Northwestern it was decided that the city should investigate the betterment of the water supply by pumping from the Des Moines River for both the city consumers and the railroad. The proposition appearing feasible after making the preliminary survey, a special election was held at which time $180,000 worth of bonds were voted, about 98 per cent of the vote being for the improvement. Provision was made for the purchase of the necessary land along the Des Moines River, and for

[1] Presented before the Iowa Section meeting, October 25, 1923.

[2] Superintendent of Water Works, Boone, Ia.

the construction of a suction system, reservoir, building and equipment at the river station, supply line from the river to the city station and reservoir, building and equipment at the city station.

The site purchased for the river station improvements consisted of about 60 acres located on the east bank of the river and extending about $\frac{3}{4}$ mile north and south. Incidentally, this site lies in one of the most picturesque spots in the Des Moines River Valley. Imagine a valley 200 feet deep, $\frac{1}{4}$ mile wide at the bottom, and from $\frac{1}{2}$ to $\frac{3}{4}$ mile wide at the top and you have an idea of this region. Up to the present time this site has been practically inaccessible to automobile traffic and large numbers of Boone people have never seen the source of their water supply. However, within the past year, the County has built a fine bridge across the river within $\frac{1}{4}$ mile of the pumping station and is now engaged in building a road to this bridge which will have a grade not to exceed 8 per cent in getting from the valley to the upland. Anticipating many visitors to the pumping station when this road is completed, the water department has planned a connecting road from the plant to the main highway. This road will be built according to good landscaping principles providing for easy curves up to the point where it crosses the small creek. A planting plan has also been secured from a reliable landscape architect, so that by the planting of shrubs and trees, most of which can be secured locally, around the building and reservoir, the scars made by man may be effaced or made to blend into the natural background. On some of the hillsides it is planned to start walnut trees so that some future generation may secure some profit as well as beauty from this otherwise unproductive ground. At a later date, parking space for autos will be provided, dutch ovens and picnic tables built and fountains set up so that the public may feel free to use the grounds for recreation purposes.

As you can see by the map, the water works grounds extend about $\frac{1}{2}$ mile up the river from the pumping station. This piece of ground is flat and here was constructed a suction system consisting of ten wells with metal screens connected with the pumping station by means of 18-inch cast iron main. Another system of wells was placed on an island in the river located opposite the pumping station and connected to it by an inverted siphon main. About two years ago, two Kelly concrete screened wells were constructed on the island and these wells together with eight metal screened wells (all on the island) now constitute the source of supply, the system on the flat

being shut off on account of diminishing supply. The strata in which the island wells were sunk consist of coarse sand and gravel yielding water readily and at the same time giving natural filtration.

Two low lift pumps are connected to this system, one duplex steam unit used as a standby and one electric motor driven centrifugal in regular service. Both pumps are located in pits. Either of these pumps can be used to take the supply from the wells and elevate it into an open reservoir of one and one-quarter million gallons capacity.

Water is taken from this reservoir by either of two steam units under a slight head and delivered to the city with the tower at the city station acting as an equalizer. The main unit on this lift is a Corliss cross-compound, duplex, condensing pump. Steam is furnished by two 150 h.p. Scotch Marine boilers. Coal is brought to the top of the hill by the Chicago and Northwestern Railway and lowered to the bunkers over a narrow gauge cable railway. All coal is weighed as it comes to the boilers.

The working head on this lift is about 165 pounds when delivering 1700 gallons per minute. The static head is about 140 pounds. Between the reservoir and the pumps the water supply is treated with liquid chlorine gas, delivered by a Wallace and Tiernan chlorinator. Leaving the pumps, the water passes through a 14-inch cast iron pipe supply line 20,000 feet long. On account of the heavy pressure the first quarter of a mile of this line is composed of Class D and C pipe. After reaching the top of the hill it is composed of Class B pipe. This supply line passes through the city on its way to the city station and the gridiron system is cross-connected at several points, check valves being provided to keep any extra pressure from coming back into the supply line. The first cross-connection is about 10,000 feet from the river station and the frictional loss to this point is about 17 pounds. Three thousand feet further there is an additional loss of 5 pounds while on the last 7000 feet the loss is only 3 pounds due to the numerous cross-connections.

The present water tank at the city station into which the supply line empties is a relic of village days, having a capacity of only 20,000 gallons. Consequently, an overflow pipe has been arranged to take the surplus water from the tank to the city station reservoir. During the past, the river station has been operated only two shifts per day of eight hours each, the excess water required for the balance of the day passing over the tank into the open reservoir at the city station. This reservoir has a capacity of three and one-third million gallons

and is the main storage unit. When the river station is not in operation (usually from 11:00 p.m. to 7:00 a.m.) the supply of water is taken from this reservoir by an automatically controlled electrically driven centrifugal pump which starts and stops according to the height of the water in the tank. A steam unit, consisting of a Meyer gear, cross-compound, condensing, crank and flywheel, pump supplied with steam by two 125 h.p. scotch Marine boilers is kept as standby. This night repumping is naturally a dead loss and can be eliminated by the construction of an elevated tank of larger capacity. Recommendations have been made to the city council, covering this improvement, the tank, when built, to be located along the supply line west of the business district. When this plan is carried out, the city station will be kept in readiness as an emergency plant only.

The site of the city station covers a city block and is ample for all needs. Being in a residential district, plans were made some time ago to make it a beauty spot, instead of an eyesore which it had been in the past. During the past summer it has been regraded, and trees, grass and shrubs planted. Some curbs and sidewalks were also built.

The buildings at both stations being nearly new are in good condition. All woodwork and roofs are painted regularly. Interior walls except the boiler room at the city station have been painted and trimmed in appropriate colors. Boiler fronts, piping and pumps have also shared in this process. Such treatment not only prevents deterioration but is really the cheapest in the long run. Greater efficiency and higher morale of employees is also gained by the judicious use of the paint brush.

The distribution system consists of 35.45 miles of Class B cast iron pipe of which 45 per cent is 4 inches, 30 per cent is 6 inches, 14 per cent is 8 inches and 11 per cent is larger. The pressure in the business district is about 45 pounds, and the fire flow is nearly 3000 gallons per minute. In the residential district the fire flow varies from 400 to 1000 gallons per minute. It is planned to build the new tank at a greater elevation so as to give a pressure of 60 pounds which will increase these flows considerably. The distribution system has over 300 gate valves and 401 fire hydrant connections of which over 98 per cent have auxiliary gate valves. The distance between streets is not great in our city and hydrants have been placed at each intersection accounting for the large number. According to the Fire Insurance Service Bureau, Boone has the largest number of hydrants per

capita in the State and is up to the Bureau's standard in this regard. All hydrants are inspected regularly particularly in freezing weather.

The Water Department as graded by the Insurance Service Bureau is rated about 40 per cent deficient. The balance of the city is about 66 per cent deficient. This difference in rating causes the city as a whole to receive a deficiency charge for the other departments are not in a position to take advantage of the fire fighting facilities offered by the water department.

The Boone Water Works is peculiarly situated in regard to consumers in that one consumer takes more than 60 per cent of the pumpage, the Chicago and Northwestern Railway using over 600,000 gallons per day. Four 3-inch meters register the supply to the railroad. All other services, of which there are 2400, are connected with meters of proper size. The average consumption of water (including railroad) is about 85 gallons per capita per day.

The income of the water department for 1922 was as follows:

City Services	$45,509.13
Chicago and Northwestern Railway	22,798.09
3 mill levy	5,760.00
Miscellaneous	946.63
Total	$75,013.85
Cash costs	49,336.39
Difference	$25,677.46

This period covered both the coal and railroad strikes so that the cost was higher and the income lower than the ordinary average.

All extensions to mains and additions to equipment are financed out of the profits from the system. The same method is used to retire bonds, $63,000.00 worth having been taken up in the past five years.

The water department is directed by a Mayor and seven Councilmen with a Water Works Committee of three Councilmen. This method is probably not as desirable as the Trustee system, but has worked out satisfactorily in this City.

THE IMPOUNDING RESERVOIR, ITS TROUBLES AND THE REMEDIES[1]

By H. L. Shaner[2]

Water is not only a beverage, but in an indirect sense a food. Water is a solvent as well as a carrier and when stored creates a medium for the growth of microörganisms, supplying their essential food and shelter. In these facts much danger lies.

The principal use of impounding reservoirs is to hold the excess water of the winter and spring floods and make it available during the summer and fall. They also serve to a less extent in some instances to hold the water of wet years and make it available in dry years.

The passage of water through large impounding reservoirs brings about certain changes in the character of the water, all tending to improve the sanitary quality and before the outlet is reached not only has a very considerable amount of purification taken place but the physical character of the water is also much improved, at any rate to such an extent that ordinarily it is an easy matter to remove the remaining pollution by filtration and sterilization.

The disappearance of pathogenic bacteria from waters held in storage in large impounding reservoirs is favored by several different agencies. Among these are, sedimentation, dispersion, sunlight, lack of food supply and possible oxidation. In many instances it has been shown that as much as 75 per cent, or in some cases as much as 90 per cent, of the bacteria in the water will settle to the bottom of a large impounding reservoir in the course of time. It is also known that many bacteria cannot live in strong sunlight and that, in clear transparent waters, the sterilizing action of light is considerable. At considerable depths the dissolved oxygen in the water is gradually consumed by the decomposition of the organic matter in the water and hence for those bacteria which require the presence of oxygen, the condition may ultimately become so unfavorable as to cause them to die.

[1] Presented before the North Carolina Section meeting, November 12, 1924.

[2] Commissioner of Public Works, Winston Salem, N. C.

These are some of the benefits derived from storage reservoirs. On the other hand, the impounding of water accumulates and breeds troubles, to which reference will be made later.

FILTRATION

It is admitted, in the light of present day standards, that no surface water supply, impounded or otherwise protected, is wholesome, safe or should be delivered to a community for drinking purposes, unless filtered and sterilized. There was a time, however, when filtration was looked upon as a luxury, but in this day of enlightenment it is considered a necessity. Therefore, in so far as this paper is concerned, this essential part of the water treatment plant will not be touched upon.

STAGNATION

All relatively large bodies of fresh water become stratified in this climate during the summer months. The warm summer sun raises the temperature of the surface water, so that it becomes appreciably lighter than is the water at a distance of 10 or 15 feet or more below the surface. This stratification, due to differences in density between the surface and lower layers, is so well defined that there is substantially no commingling of the bottom and top waters.

In the bottom waters, however, there are present accumulations of organic matter, caused in part from leaves and other matter washed in with the entering streams of water, and in part from the growths of algae, which, on earlier occasions, have developed in the surface water, died, and settled to the bottom. The ordinary bacteria coming from the washings of the soil enter the impounding reservoir and cause this organic matter of strictly vegetable origin to decompose just as do the leaves in the forest. As this process of nature continues, it consumes all of the atmospheric oxygen present in the bottom layers of water, which have no opportunity to replenish oxygen, as they are separated from the atmosphere by an overlying stratum of water of less density. Ultimately all of the oxygen in the bottom water is exhausted and the water is then said to become "stagnant."

In the absence of oxygen the organic matter still continues to decompose, but the decomposition is in another way. The decomposition that takes place in the absence of oxygen is called putrefaction. Anaerobic decomposition or putrefaction produces some

objectionable odors and tastes, which are confined for a time to the bottom layers of stratification.

The cool autumn nights reduce the temperature of the surface water, until its density becomes as great as that of the bottom layers of water. When this occurs there is a mixing of the water from top to bottom, a condition that is apt to remain for several weeks, which is called the fall turnover. The odors and tastes stored up in the bottom water then become mixed with all the waters in the reservoir.

Stagnant water of impounding reservoirs possesses some color or vegetable stain, due to the extract of leaves and vegetable growth, all of which when combined with iron extracted from the soil at the bottom of the lake has a tendency to make the color unusually pronounced.

The stagnation of water is not so objectionable in itself, the offensive tastes and odors are due principally to the gases of decomposition such as, sulphureted, carbureted, phosphoreted hydrogen, and not to growths of organisms. The fungi are usually the only organisms found growing prolifically in stagnant water and they do not directly cause objectionable tastes and odors. If by chance the bottom waters become infested with growths of crenothrix, then a different story is told, as those organisms do cause very objectionable tastes and odors.

ALGAE GROWTHS

The microörganisms found in the waters of impounding reservoirs may belong to either the animal or vegetable kingdom. These plants and lower forms of animal life may be of one or many-celled origin and in so far as they are related to practical water works operation may be roughly classed as follows.

The diatoms, uni-cellular plants possessing silicious cell walls upon which are certain markings of great beauty, usually occurring when the temperature is around 50°F. and imparting to the water an aromatic odor.

The green algae of all shades containing chlorophyll, uni-cellular or multi-cellular plants, with or without a nucleus of starch grains and often inclosed by a cell wall of cellulose or gelatine, usually in the water when the temperature is about 60° or 70°F. and imparting to it a grassy or fishy odor.

Crenothrix, the iron bacteria living in the dark in waters rich in iron salts and carbonic acid and deficient in oxygen. This organism also grows in pipes and is objectionable, imparting to the water a vile odor. Sometimes found in the bottom layers of stagnant water in summer and in all depths in autumn after the fall turnover.

Fungi, the parasitic plant lacking chlorophyll and starch, living for the most part upon dead organic matter in the stagnant bottom waters of impounding reservoirs.

The protozoa, rotifera and crustacea are the principal micro-organisms of the animal kingdom found in impounding reservoirs. They take their food from the albumens, fats, sugars and starches insoluble in the water. They differ from the plants in that they cannot exist upon or take up carbon, oxygen, hydrogen and nitrogen from mineral matter dissolved in the water. They, must possess, therefore like the higher forms of animals, organs for obtaining and digesting their food and for reproduction, generally present in the water at all seasons from spring to autumn and imparting to the water usually a fishy odor.

With the exception of the fungi, crenothrix and certain forms of the animal group these microörganisms usually flourish in the upper layers of the waters of impounding reservoirs and require sunlight for their existence. They originate mostly in the warm shallow pools of the head waters of the reservoir and around and near the edges of the banks, from which breeding places they are scattered throughout the waters of impounding reservoirs by the gentle breezes or perhaps by the inherent migratory characteristics possessed by the organisms.

It should be explained that these growths do not indicate objectionable pollution as they are to be found in the flow of the purest spring waters. It has been claimed by some, however, that certain intestinal diseases especially among young children and invalids can be traced to drinking waters rich in microscopic organisms and that the decomposition of the organisms by bacterial action contribute to such disorders.

Whether or not these growths have a direct bearing upon the public health, they are objectionable from the standpoint of taste and odor. In part the taste comes from the decomposition of the dead organisms and in part from tiny oil sacks, which release penetrating oils of a pungent, although harmless, nature.

Cold water holds gases and odors in solution better than warm

water. This is one of the reasons why cold water tastes and smells better than water which has been heated. If objectionable odors are present they are released when the water is warmed by cooking or by the heat of the stomach, and are taken up by the food being cooked or by the system of the individual.

CARBONIC ACID GAS

Carbonic acid gas, the product of decomposition, is ever present in the waters of impounding reservoirs to a greater or less extent. Its production is the result of the rotting of organic matter and the respiration of animals, both dead and living algae contributing to its formation.

During the stagnation period the reservoir becomes a veritable generator for the production of this gas and the water becomes saturated with it. In the process of filtration, by the reaction of alum with the natural alkalinity of the water, more of this gas is picked up, resulting in a water containing at times as high as 25 or 30 p.p.m. CO_2 gas for delivery to the pipe system.

Carbonic acid gas renders the water more solvent, increasing its corrosive or rusting properties, thereby causing it to attack more readily the iron of the pipe system. In conjunction with organic matter tubercles form on the inner surface of iron pipes and the effect is materially to decrease the capacity of the pipe by increasing the frictional resistance.

REMEDIES

There is no known method of preventing the waters of impounding reservoirs from becoming stratified and stagnating during certain periods of the year.

The gases of decomposition perhaps could be controlled by following the old Massachusetts custom of soil stripping, that is removing from the sides and bottoms of the reservoir all soil so as to eliminate at the outset all organic matter.

This method in itself would not entirely do away with all organic matter, unless it is possible to imagine a catchment area city-owned, free from all human habitation, covered with forest and maintained at all times in a clean and sanitary condition. This ideal condition of the catchment area would in most cases be impracticable of attainment on account of the expense involved.

Therefore, on account of cost, the odors of decomposition, with its complement of CO_2 gas, must be treated in some way rather than an attempt made to prevent their formation.

With small quantities of lime added to the water at times, it is possible to control the amount of carbonic acid so that the filtered water will have less corroding effect on metal pipes and thereby avoid in a measure "red water troubles."

This general method of lime treatment has been practiced at Winston Salem with some measure of success. It has been found that it is possible to reduce the CO_2 gas from 15 to 4 p.p.m. by using about 100 pounds of commercial lime per million gallons of water treated. The lime is applied to the filtered water as it enters the clear water reservoir. The lime used is bought locally and was low in water soluble calcium oxide. Smaller quantities of lime higher in water soluble calcium oxide would have given the same results. It is our intention next year to purchase lime in car load lots and to specify lime containing at least 88 per cent water soluble calcium oxide.

Algae growths may be controlled and regulated, but not exterminated, by the use of copper sulphate, ordinary commercial crystals of blue vitriol.

If the copper sulphate is applied systematically, in proper quantities, and with sufficient frequency it will no doubt keep these microörganisms ordinarily down to small or moderate quantities.

For some time the great value of copper sulphate as a fungicide has been recognized. That copper exerts a toxic effect is well known. It is uncertain just how copper sulphate acts in the destruction of algae, but it appears to react with the albumen of the algae to form an insoluble substance which sinks to the bottom of the pond. This precipitated copper on the bottom of the bond, after it has ceased to be in a colloidal condition does not appear to be objectionable.

The method of reaction according to the best authorities is about as follows:

The sulphate of copper reacts with calcium bicarbonate, which is present to a greater or less extent in nearly all natural waters to form sulphate of calcium and basic copper carbonate, some carbonic acid being liberated. The basic copper carbonate may then become decomposed, copper hydrate and carbonic acid being formed. Copper hydrate is almost insoluble in water. Basic copper carbonate is somewhat soluble in water which contains carbonic

acid, especially if the hardness of the water is low. Experiments have shown that in hard waters the reaction above mentioned takes place in the course of a few hours, the copper hydrate first becoming a colloid and then precipitating as solid matter in suspension. In softer waters the reaction takes place more slowly. It seems probable, however, that the reduction of the carbonic acid brought about by the organisms themselves may hasten the reaction. The presence of organic matter in solution tends to retard it. The reaction is more rapid in warm than in cold water. The precipitation of the copper hydrate is hastened by the presence of suspended matter. This is probably a physical action.

The theoretical amount of chemical to be applied to the water in any case is tedious to ascertain as it is dependent upon so many variables. The principal factor, however, and one that should be determined closely is the quantity of water to be treated, usually in practical operation this is about all that is necessary to be known.

It is our practice at Winston Salem to attempt to control and regulate the growth of algae in our reservoir. We have found it to be more effective to kill these microörganisms at their point of origin, than to wait until these growths become luxuriant and scattered throughout the pond. Therefore, the impounding reservoir is treated periodically at regular intervals of about thirty days from March to October.

At Winston Salem we have used about 1.7 pounds of copper sulphate per million gallons of water treated. At Lynchburg, Virginia, as high as 2½ pounds of copper sulphate per million gallons were used. Next year at Winston Salem the dose will be increased probably, using as much as 2½ pounds per million gallons. I would not hesitate to use a larger dose if necessary to exterminate these algae growths, probably as much as 3 or 4 pounds per million gallon. Of course, no more copper should be used than is necessary to eradicate the microörganisms and care should be taken to avoid overdosing the reservoir. At the same time it should be remembered that the copper is used for the purpose of removing from the water these objectionable growths and a sufficient quantity of chemical should be applied in order to accomplish this purpose. The reservoir at Winston Salem holds about one billion gallons of water in storage and, consequently, at each treatment last year we used 1700 pounds copper sulphate. This will be increased next year to 2500 pounds. In between these regular treatments the edges of the reservoir are dragged and the shallow pools at the head waters are treated with a small amount of copper sulphate. In this intermediate treatment about 1000 pounds of the chemical are used.

Therefore, on account of cost, the odors of decomposition, with its complement of CO_2 gas, must be treated in some way rather than an attempt made to prevent their formation.

With small quantities of lime added to the water at times, it is possible to control the amount of carbonic acid so that the filtered water will have less corroding effect on metal pipes and thereby avoid in a measure "red water troubles."

This general method of lime treatment has been practiced at Winston Salem with some measure of success. It has been found that it is possible to reduce the CO_2 gas from 15 to 4 p.p.m. by using about 100 pounds of commercial lime per million gallons of water treated. The lime is applied to the filtered water as it enters the clear water reservoir. The lime used is bought locally and was low in water soluble calcium oxide. Smaller quantities of lime higher in water soluble calcium oxide would have given the same results. It is our intention next year to purchase lime in car load lots and to specify lime containing at least 88 per cent water soluble calcium oxide.

Algae growths may be controlled and regulated, but not exterminated, by the use of copper sulphate, ordinary commercial crystals of blue vitriol.

If the copper sulphate is applied systematically, in proper quantities, and with sufficient frequency it will no doubt keep these microörganisms ordinarily down to small or moderate quantities.

For some time the great value of copper sulphate as a fungicide has been recognized. That copper exerts a toxic effect is well known. It is uncertain just how copper sulphate acts in the destruction of algae, but it appears to react with the albumen of the algae to form an insoluble substance which sinks to the bottom of the pond. This precipitated copper on the bottom of the bond, after it has ceased to be in a colloidal condition does not appear to be objectionable.

The method of reaction according to the best authorities is about as follows:

The sulphate of copper reacts with calcium bicarbonate, which is present to a greater or less extent in nearly all natural waters to form sulphate of calcium and basic copper carbonate, some carbonic acid being liberated. The basic copper carbonate may then become decomposed, copper hydrate and carbonic acid being formed. Copper hydrate is almost insoluble in water. Basic copper carbonate is somewhat soluble in water which contains carbonic

acid, especially if the hardness of the water is low. Experiments have shown that in hard waters the reaction above mentioned takes place in the course of a few hours, the copper hydrate first becoming a colloid and then precipitating as solid matter in suspension. In softer waters the reaction takes place more slowly. It seems probable, however, that the reduction of the carbonic acid brought about by the organisms themselves may hasten the reaction. The presence of organic matter in solution tends to retard it. The reaction is more rapid in warm than in cold water. The precipitation of the copper hydrate is hastened by the presence of suspended matter. This is probably a physical action.

The theoretical amount of chemical to be applied to the water in any case is tedious to ascertain as it is dependent upon so many variables. The principal factor, however, and one that should be determined closely is the quantity of water to be treated, usually in practical operation this is about all that is necessary to be known.

It is our practice at Winston Salem to attempt to control and regulate the growth of algae in our reservoir. We have found it to be more effective to kill these microörganisms at their point of origin, than to wait until these growths become luxuriant and scattered throughout the pond. Therefore, the impounding reservoir is treated periodically at regular intervals of about thirty days from March to October.

At Winston Salem we have used about 1.7 pounds of copper sulphate per million gallons of water treated. At Lynchburg, Virginia, as high as 2½ pounds of copper sulphate per million gallons were used. Next year at Winston Salem the dose will be increased probably, using as much as 2½ pounds per million gallons. I would not hesitate to use a larger dose if necessary to exterminate these algae growths, probably as much as 3 or 4 pounds per million gallon. Of course, no more copper should be used than is necessary to eradicate the microörganisms and care should be taken to avoid overdosing the reservoir. At the same time it should be remembered that the copper is used for the purpose of removing from the water these objectionable growths and a sufficient quantity of chemical should be applied in order to accomplish this purpose. The reservoir at Winston Salem holds about one billion gallons of water in storage and, consequently, at each treatment last year we used 1700 pounds copper sulphate. This will be increased next year to 2500 pounds. In between these regular treatments the edges of the reservoir are dragged and the shallow pools at the head waters are treated with a small amount of copper sulphate. In this intermediate treatment about 1000 pounds of the chemical are used.

AERATION

Without doubt the key-note of success in treating the stored waters of impounding reservoirs is in aeration. The intimate contact of water in minute particles with the atmosphere restores the oxygen to the water and liberates objectionable gases with foul odors, as well as carbonic acid gas.

This can be accomplished by the exposure of the water to the air in thin films, in drops or as a fine spray, through nozzles designed for the purpose.

An aerator of the circular ring nozzle type which is now in successful operation at the Lynchburg, Virginia, works has been known to reduce carbonic acid gas from 25 p.p.m. in the filtered water to 3 p.p.m. and to remove at the same time all odoriferous gases. An aerator of similar design, though larger, will be installed and placed in operation at Winston Salem sometime during next year. The contract for its erection has already been awarded.

A majority of the vegetable organisms which produce offensive taste and odors grow in the upper layers of the water of impounding reservoirs where sunlight and warmer temperatures are available for promoting these growths. Unless these algae growths are controlled and regulated by the systematic application of copper sulphate in proper quantities and with sufficient frequency, at such times it is much easier to treat bottom stagnant water than the top water containing these heavy growths, as aeration would have a tendency to break up the delicate structures of plant life and release the penetrating odor producing oils.

Stagnant water can be freed from its objectionable odors by energetic aeration, although the contact with the oxygen of the air will precipitate some of the iron compounds as solid matter, which can be readily removed by sedimentation or by filtration.

CONCLUSIONS

Lime treatment will neutralize CO_2 gas, but will not remove tastes and odors or restore oxygen to stagnant water.

Copper sulphate applied periodically at regular intervals will regulate and control algae growths, but will not eliminate them altogether. This treatment will not remove tastes and odors due to the penetrating oils which they release nor the odors of their decomposition.

Aeration combined with copper treatment and filtration will, at all times, produce a safe, pure water of satisfactory and attractive appearance and free from taste and odors. Neither filtration nor aeration alone will accomplish this end.

DISCUSSION

C. M. Whitlock:[3] I shall touch on a phase of algae troubles that Mr. Shaner did not cover particularly, that is, the clogging of sand filters with live microörganisms. In doing this I am simply going to narrate our experiences this past summer. Suddenly our filters started to clog badly, holding us down to five or six hours run. After looking to mechanical sources that could be causing the trouble we did not find any, and decided it must be due to micro-organisms. Subsequent analysis confirmed this. We started dosing with copper sulphate, using 0.3 part per million dose. We did not get results and gradually we raised our dose, increasing to one part per million. Our better runs rose to twenty-two hours. This is our customary run, as we had no mixing chamber and the retention period in the coagulating basin we were using at that time was inadequate, being only fifteen to twenty minutes. This trouble continued for two or three months. As soon as we stopped the copper sulphate the filters would fill up immediately and we would go back to the one part per million dose and obtain an adequate run. There was no manifestation except clogging, no mat on the filter, no odor, no gas, no growth, no phenomena except the clogging of the filter. It continued all during the warm weather. We found no harmful effects in using one part per million. We first tried cleansing the filters and basins with copper sulphate and then drawing the liquor off and cleansing it again, but it did no good at all. The only thing we could get results with was the continued copper sulphate dosing. We tried chlorination, both with and without the copper sulphate, without beneficial results. We also fixed up a portable solution tank with a constant head orifice box and tried the effect of the dosing at various points on the filters and in the coagulating basin. We found that the best results were obtained by applying the copper sulphate just as the raw water came into the coagulation basin.

The above is a radical departure in the use of copper sulphate. I wish to be sure that no one will take this outline of our experience in

[3] Superintendent, City Water and Light Department, Mt. Airy, N. C.

the light of research or experimental work. Although we found no trace of copper in the clear well, I should like to suggest that any one using our experience as a precedent should be sure to confirm this.

E. A. WIDENHOUSE:[4] Mr. Shaner has covered the subject thoroughly. We have a practically new pond, as it has been in use for two years and we have not developed very much algae. At least it has not been very perceptible yet. We had slight odors and taste. The odors in the raw water pond especially were noticeable. We aerate before the water goes into the mixing chamber and that has helped a great deal. We usually treat the raw water pond by using a motor boat. I usually use about one part per million dose, about every two weeks during the summer when it is noticeable. I have had good results and have practicallly eliminated all the taste and most of the odor—all the odor, as far as one can tell in cold weather, but it was a little noticeable in hot weather.

A. O. TRUE:[5] I think Mr. Shaner's paper is a very valuable contribution to this subject. At Proximity Mills we have had considerable trouble from algae. I believe I reported last year some of my troubles along this line. The question of algae is one of considerable important in all filter plants which draw their raw water from a reservoir which stands in the sunlight and has a chance to generate the conditions which Mr. Shaner has so carefully described to us.

Our trouble at Proximity has been a little different from Mr. Shaner's or from that of the other gentlemen who have spoken. It is not so much from the live algae as it is from what I consider the products of the dead algae. A great many of these algae are of the floating type—they are of the plankton or wandering algae, some on the surface, some distributed through the water. In time they die and disintegrate. The result of this decomposition seems to be a gelatinous substance, amorphous in character. That material is of rather peculiar physical character. It does not seem to be readily removed by alum treatment, at least I have not been able to remove it considerably by coagulation. It seems to leave the coagulation basin and get on the filters. Ordinarily one cannot see it, except once in a while at the outlet of the coagulating basin it puts in

[4] Water and Light Department, Albermarle, N. C.

[5] Sanitary Engineer, Proximity Manufacturing Co., Greensboro, N. C.

appearance in the form of a scum. It gets on the surface of the sand and forms a sort of water proof coating, I have had the occasion when my filters would develop a maximum loss of head within three-quarters of an hour. I have had them run shorter even than that.

As I reported at the last convention, about the only relief we could get in washing our filter was to "crack" the filter, as the expression goes—open the wash water valve and put a mimimum amount of wash water through, and relieve the condition. If the filter were washed for several minutes, there apparently would be no suspended matter removed, no mud or such matter when you wash your filter ordinarily. The sand, if you examine it carefully, gives the appearance, of having a sort of waterproof coating, of gelatinous material. This same trouble has been reported in Baltimore.

I am not in position to state the cure for that sort of thing. Last year we treated our reservoir with copper sulphate. This reservoir is a large body of water, covering about 87 acres. I postponed treatment during the early part of the summer, thinking I had better wait until after the rains were over. I waited until the latter part of July. I think it was about the 26th or 27th of July I applied the copper sulphate at a dose of 0.25 p.p.m. Unfortunately, on the 28th of July, after I had been careful to wait so long to get over the rainy season we had at the filter plant at Proximity eight inches of rain in one day. The reservoir which was down at that time three feet below the spillway, in a few hours was flowing over the spillway, and the effect of my copper sulphate was completely masked; in other words I do not know what the effect was, because after this heavy rain and the copper sulphate my condition cleared up.

There is another thing about the condition or appearance of these algae. There does not seem to be any regularity about it. In the old days when this trouble first arose, in the days of slow sand filters, the supposition was it was a hot weather proposition, but it was soon discovered that it did not necessarily occur in hot weather, and that has been one of the peculiar features about the plant at Proximity. We will be going along a week or two pretty well, without much trouble from algae, when suddenly without any warning or any change apparently of conditions these growths appear and reduce our filter runs to a very few hours. There are probably, therefore, a good many facts about the distribution and life history of algae that we do not yet know.

In regard to the generation of carbon dioxide, that is an important

feature in a reservoir such as we have. I find it is always best to take the water from the top or as near the top as possible. In the design of plants using such a condition as that, it is important to have plenty of intake ports. We got into trouble the first year at Proximity on that account. We had only two ports and got below the first port before we realized our trouble. It necessitated putting in a new port, in order to obtain water near the top. The water as drawn from the bottom of our pond will run probably 45 parts per million of carbon dioxide. I have never been able to coagulate the water having a carbon dioxide content as high as that. It can be neutralized by using alkali, but it took about eight grains of alkali in order to get any coagulation and that can be tasted in the water, so I did not feel justified in using any such amount as that.

J. E. Gibson:[6] In Charleston we have a regular algae incubator in storage reservoir. The storage reservoir covers about three square miles with an average depth of not quite three feet. In days gone by when rice culture was the principal industry it was a rice field. It probably does not run over 4 to 5 feet deep, and in the summer months particularly the water will reach a temperature of 80°F., so algae are prolific. I think Mr. Bunker, when he was making tests in 1904–1906, found 200 different species of algae and I am certain he did not cover all.

We use copper sulphate continuously from about the first of March until probably the first of November. Sometimes we use it after that. Our average consumption will run 100 to 150 pounds a day during the worst part of the season. We will pump about five and one-half million gallons of raw water. A portion of that is put in our sedimentation basin and about 0.25 p.p.m. used in the clear water basin. It is an open clear water basin and about 10 or 12 feet deep. Algae would grow in that basin, so by using about a quarter of a part per million I could stop the growth of algae on our walls. We keep it white washed and it looks much more esthetic. In the impounding reservoir for a space of 500 to 600 feet around our intake, we use from 100 to 120 pounds per day, put in at six-hour intervals during the height of the season.

I have tried to find some way to put it in more effectively. We simply use a boat and the old gunny sack and trail it around, as I

[6] Manager and Engineer, Water Department, Charleston, S. C.

have not figured any other way I could cover a big area without great expense.

With reference to taking water from the surface, it is not always wise to do this. I found that out to our sorrow this year. Until the past season our intake was located 2000 feet from the shore and about 10 feet below the surface. During the past season we had to put in a new intake. We put it closer to the shore and arranged it so we could take the water from the surface. The first thing we knew, we were having filter troubles of all kinds, clogging up and getting odor in our filtered water. Of course, our microscopic examinations showed what we were suffering from. We then began to increase the dose of copper sulphate around our intake and further out in the stream, but our most effective measure was to put a baffle in front of the intake so as to get the water about 6 feet below the surface. Within twenty-four hours after that we got relief from our filter clogging. In the course of a few days we mastered the algae trouble so that we could go back to the surface, but we continued below the the surface for a period well into the fall. We are now taking from the surface again.

Speaking generally, the surface water is best. We have made hundreds of tests to try to find copper in the filtered water when we treated the clear water basin. We have yet to find any trace of copper. What becomes of it I do not know. It must settle to the bottom and lie there. We wash the basin out at periodic intervals, so there is no accumulation there, but we have never found a trace of copper in the filtered water.

CHARGES FOR AUTOMATIC FIRE SPRINKLER SYSTEM[1]

A Review of the Indiana Public Service Commission Decision

By Luke Ellis[2]

This petition was denied by the Commission because of the well-established fact that the automatic spinkler charge is nothing more nor less than a ready-to-serve charge which is included in the rate schedule of every public utility furnishing electric and water service in the State of Indiana.

The principal averment of the petitioners was,—that the charge for this water connection imposes an additional burden on the automatic sprinkler owners and is a discriminatory tax; and that it tends to destroy the interest of the average property owner in equipping his property for the reduction of fire peril.

Petitioners introduced considerable evidence to show the unreasonableness of the automatic spinkler charge herein complained of, but also set forth the fact that the fire hazard in factories is greatly reduced by the automatic sprinkler system; that properties adjacent to factories having such automatic fire sprinkler systems receive the benefit of additional protection; and that such systems result in benefit to labor by making possible its continuous employment, because of the preservation of the factories so equipped. However, petitioners failed to make reference to the fact that no device has any merit or would be of any benefit whatever without an abundant water supply ready with sufficient pressure to force it wherever and whenever needed.

Evidence was also introduced by petitioners to show that inasmuch as very little water is used in this service, no expense is attached to

[1] In the matter of the petition of McFerson & Foster Company, and fifty other business firms of the City of Evansville, Indiana, vs. City of Evansville (Waterworks Department) for discontinuance of charge for Automatic Sprinkler Systems. Before the Public Service Commission of Indiana, No. 7795, Approved, February 27, 1925.

[2] Service Engineer, Public Service Commission of Maryland, Baltimore, Md.

the waterworks department in furnishing the same, and accordingly, no charges should be made for the service.

The Commission does not agree with this argument. In fact the question is not one which concerns the quantity of water used, but does relate to the expense necessary to provide sufficient and adequate equipment to render the service demanded by petitioners in event of a fire.

The automatic sprinkler charge made to petitioners in this cause is based upon the size of pipe used, the larger the pipe the greater the cost of service rendered. The evidence shows that for a 1-inch pipe used for fire sprinkler purposes in the city of Evansville, the cost per annum is $10; for a 6-inch pipe the cost per annum is $96; and that in practically every instance petitioners' equipment is for the 6-inch connection. If petitioners' contention is reasonable, that no charge should be made if no water is actually consumed, then would it not have been to their financial advantage to install the 1-inch equipment? Certainly, there should be a reasonable charge not only for the immediate use, but for the privilege of using as large a quantity of water as possible at the highest pressure.

The Commission believes the ready-to-serve charge to be the only reasonable and equitable charge applicable to this class of service, and it is so recognized throughout the country. The same rule applies to electricity. Where the equipment is constructed to supply current for a 100 k.w. transformer and motor, that cost is very much greater than with equipment to supply current for a 25 k.w. transformer and motor.

The historical development of the Evansville water plant and system shows that because of the existence of these automatic fire sprinkler systems much of the utility's plant equipment was planned and installed upon a larger scale than otherwise would have been necessary.

In view of the fact, as hereinbefore stated, that the rate for this service is a ready-to-serve charge, the granting of petitioners' prayer would create a discriminatory condition and necessitate the readjustment and elimination of every ready-to-serve charge in the schedules applicable to consumers of both electric current and water in the state of Indiana.

The ready-to-serve charge is made on fire hydrants not because of the amount of water used through them, but because of the necessary cost to the water utility in order that it can be ready at all times to

meet any demand upon the hydrant. The quantity of water used through the hydrant is very small. In fact hundreds of hydrants have never had a hose attached to them for the purpose of extinguishing a fire.

Petitioners complain of double taxation, that is to say, that the automatic sprinkler system is assessed as personal property to the owner, and of course additional tax is levied on its value, which does not apply to other taxpayers who use water. This contention is well taken except for the fact that the charge is not for the quantity of water used, but for sufficient and adequate equipment which is ready at a moment's notice to supply the demands of the consumer. Suppose the water department would extend a main into a new district and supply this district with the regular number of fire hydrants such as applies to other districts, and the city of Evansville, because of extra fire hazards, would request additional hydrants; in this event the hydrants would be supplied and the city of Evansville would pay to the water department the regular ready-to-serve charge as is applied to other fire hydrants, although a fire hose might never be attached to the fire hydrant.

The installation of a sprinkler system operates primarily for the benefit of the plant in which it is installed because it decreases materially the fire hazard in that plant. This is evidenced by the fact that insurance companies allow a very substantial reduction in fire insurance rates where the automatic sprinkler system is installed and maintained. If no charge is collected from the patrons who use the automatic system, the expense of furnishing this service falls upon the other water consumers, who pay in proportion to the amount of water they use.

The Commission, being fully advised in the premises, is of the opinion and finds, that the petition of McFerson and Foster Company and others, should be denied, and it will be so ordered.

The Commission further finds, that the annual fire hydrant rental charge now paid by the city of Evansville to the waterworks department is not comparable with, and is much less than, the charges paid by other consumers who receive similar service, thus constituting a discrimination.

A NOTE ON THE VOGES-PROSKAUER REACTION[1]

BY C. S. LINTON[2]

The production of acetyl methyl carbinol from glucose is generally recognized as one of the distinguishing characteristics of the aerogenes section of the colon group. Observations have shown this character to be almost perfectly correlated with the methyl red test. Some recent investigations, however, have reported non-correlating results when the two tests were performed on aliquot portions of the same tube of Clark and Lubs medium incubated for five days at 30°C.

The following observations on the Voges-Proskauer reaction in 180 strains of the aerogenes group may explain some of these anomalous results. These organisms were isolated from soil and human dejecta and all were alkaline to methyl red. The following media were used for determining the Voges-Proskauer reactions:

Medium no. 1 (Clark and Lubs)

	per cent
Witte's peptone	0.5
K_2HPO_4	0.5
Anhydrous glucose	0.5
Distilled water	

Medium no. 2 (Glucose Broth)

	per cent
Difco peptone	1.0
K_2HPO_4	0.2
Anhydrous glucose	1.0
Andrade's indicator	1.0
Distilled water	

The Clark and Lubs medium was incubated at 30°C. and the glucose peptone water broth at 37°C.

The initial tests on the two media did not agree in all instances. One hundred and forty-one of the 180 strains gave distinctly positive

[1] Presented before the Iowa Section meeting, November 6, 1924.

[2] Assistant Bacteriologist, Engineering Experiment Station, Ames, Iowa.

TABLE 1

Showing effect of period of incubation on Voges-Proskauer reaction

ORGANISM NUMBER	INITIAL REACTIONS		REACTION OF RETEST				
	Andrade's peptone glucose, 24 hours 37°C.	Clark and Lubs, 5 days 30°C.	Andrade's peptone glucose, 36 hours 37°C.	Clark and Lubs 30°C.			
				36 hours	60 hours	5 days	10 days
28	+	−	Slight	+	+	−	−
29	+	−	+	+	+	−	−
34	+	−	+		+	+	+
35	+	−	+	+	+	−	−
36	+	−	+	+	+	−	−
37	+	−	+	+	+	−	−
38	+	−	+	+	+	−	−
45	Slight	Slight	+	+	+	−	−
48	+	Slight	+	+	+	−	−
61	+	−	+	+	+	−	−
62	Slight	Slight	+	+	+	−	−
63	+	Slight	+	+	+	−	−
65	+	−	+	+	+	−	−
73	+	−	+	+	+	−	−
75	+	−	+	+	+	−	−
76	+	−	+	+	+	−	−
77	+	−	+	+	+	−	−
78	+	−	+	+	+	−	−
80	+	−	+	+	+	−	−
81	+	−	+	+	+	−	−
83	+	−	+	+	+	−	−
84	+	−	+	+	+	−	−
86	+	−	+	+	+	−	−
87	Slight	Slight	+	+	+	−	−
93	+	Slight	+	+	+	−	−
97	−	+	−	+	+	+	+
98	+	Slight	+	+	+	−	−
99	+	Slight	+	+	+	−	−
100	−	+	−	+	+	+	+
103	+	−	+	+	+	−	−
114	−	+	−	+	+	+	+
118	−	+	+	+	+		+
119	Slight?	−	−	+	−	−	−
120	−	+	+	+	+		+
129	−	+	−	+	+	+	*
130	−	+	−	+	+	+	
144	+	−	+	+	+	+	

* Culture lost.

tests for acetyl methyl carbinol on both media. Thirty-nine strains, on the other hand, showed negative or faint tests on one or the other of the media. Two of the 39 strains seemed to be impure and will not be given further consideration. Of the remaining 37 strains, 27 were negative or gave a very faint test in Clark and Lubs medium after 5 days incubation at 30°C. and a distinctly positive test in the glucose broth after twenty-four hours at 37°C. Three showed slight tests in each medium and 7 were positive in the Clark and Lubs and negative in the glucose broth as indicated in table 1. Two cultures which were distinctly negative and 3 giving slight reactions in the initial test on glucose broth, using an incubation period of twenty-four hours, were found to be distinctly positive when the incubation period was increased to thirty-six hours.

The discrepancies in the results obtained in the first group of 27 strains were found not to be due to the make of peptone in the two media, but rather to the period of incubation. Thus all of those strains, which were negative in the initial trial in Clark and Lubs medium after five days, were positive on retesting after incubation periods of thirty-six hours and sixty hours respectively, whereas 25 of these 27 strains were negative again after five days incubation. This would indicate that acetyl methyl carbinol, like acidity, is a transient end product of glucose decomposition by the aerogenes group, and that when testing for its presence the incubation period must be rather short.

RÉSUMÉ

These results would indicate that the time (and possibly the temperature) has an important effect on the results secured in the Voges-Proskauer reaction. An incubation period of thirty-six to sixty hours at 30°C. in Clark and Lubs medium gave positive results with all cultures. Prolonging incubation to five or ten days in the same medium and under the same conditions resulted in many negative tests.

Acetyl methyl carbinol, like acidity, appears to be a more or less transient end product of metabolism of glucose by members of the aerogenes group.

The practice of running Voges-Proskauer tests on part of the material used for the methyl red reaction cannot be relied upon to give accurate results because of the too prolonged period of incubation.

TRANSACTIONS OF THE INTERNATIONAL CONFERENCE ON SANITARY ENGINEERING, LONDON, 1924[1]

A Review

By T. C. Schaetzle[2]

The conference of sanitary engineers, recently held at London, is of special interest to the profession. Some of the most prominent sanitary engineers of England, the Continent and the United States took an active part therein.

Although the conference was concerned with general sanitary engineering subjects, the majority of papers read and discussed had special reference to sewage treatment. The latter subject was reviewed in considerable detail with respect to activated sludge, the most recent practically developed method of sewage treatment. An interesting paper upon the activated sludge plant at the Withington Sewage Works pointed out the fact that an average of 0.92 cubic feet of free air was used per gallon of sewage treated with a normal working air pressure of four pounds per square inch, and that the surplus sludge, which amounts to approximately 2.4 per cent of the flow treated, is handled by trenching or spreading on farmlands.

In a review of the activated sludge process in the East, Professor Gilbert J. Fowler pointed out the fact that this process, as a preliminary to land treatment, has made it possible to establish sewage farms without nuisance and with the least loss of manurial value of the water-borne sewage and with the production of an excellent crop of cabbages, chillies and vegetable marrows from land which was formerly a jungle.

In a discussion of this process as used in the United States, interesting papers dealing with the situation at Milwaukee, Wisconsin; Houston, Texas and Chicago, Illinois; were read. At Milwaukee, special stress has been laid upon the treatment and disposal of the sludge in a scientific manner. The excess sludge is treated with sulphuric acid to reduce the pH value to from 3.2 to 3.6, mixing

[1] Volume for sale by American Public Health Association, New York, N. Y.

[2] Maryland State Department of Health, Baltimore, Md.

being accomplished by aeration. The sludge is next pumped through heat exchangers to vacuum continuous filters, where the moisture is reduced to from 75 to 80 per cent. The sludge is then blown off the filters, mixed with previously dried sludge and passed through direct-indirect dryers. During the cold weather months, the sludge will be heated to 120°F. before de-watering. The estimated cost of sewage treatment is $22.00 per million gallons and that of treating the sludge and screenings $13.00 per million gallons of sewage, including all over-head, interest and depreciating charges.

For the purpose of placing activated sludge on the market as a regular fertilizer, the Sewerage Commission of Milwaukee has become a member of the National Fertilizer Association and has established a fellowship in research for the use of activated sludge when applied to various crops and lawns. Thus far, the results indicate that activated sludge has a definite fertilizer value and good results have been obtained when used upon lawns.

The scientific investigation of activated sludge treatment and disposal, conducted at Milwaukee, was outlined in an interesting paper entitled, "Colloid Chemistry As Applied to Activated Sludge." As produced, the sludge particles are negatively charged electrically. This electric charge opposes the union of small particles to form larger ones. With increasing electric charge, the sludge particles tend to break up into smaller and smaller units, whereas, with decreasing electric charge, the particles tend to unite forming larger ones. Therefore, to obtain particles of sufficient size to be retained upon a filter cloth, it was found advisable to add sulphuric acid to obtain a pH value of approximately 3.4, causing the sludge to filter at five times its normal rate. The addition of aluminum sulphate followed by sulphuric acid to reduce the pH value to 4.4 also increased the rate of filtration. It was learned further that heating after acidification increased still further the rate of filtration and that the percentage increase in rate of filtration obtained by each different treatment is independent of the initial rate.

The author of this paper summarizes as follows: "By applying what has been learned of the effect of pH value, temperature and polyvalent ions upon colloidal behavior in general to the specific problem of de-watering activated sludge and by introducing certain broad principles of filtration, it has been shown how to increase the efficiency of this operation by about 4000 per cent."

At Houston, Texas, air is supplied through filtros discs having a

combined area of one-seventh of that of the surface. Some clogging has been experienced. Sludge is disposed of by lagooning, and experiments are under way to determine an economical way of preparing the sludge as a commercial fertilizer. Sulphur dioxide is being used. The cost of treatment ranges from $14.02 to $19.08 per million gallons not including interest on investment nor allowance for depreciation.

At Chicago, interesting experiments have been conducted upon spiral circulation in the activated sludge process. Observations were made using a glass aeration tank and the main demonstration unit was a rectangular flat bottom tank equipped with deflecting surfaces to direct the flow and to increase the circulating velocity. An increase of 100 per cent in velocity was secured when the deflectors were placed at a 45 degree angle with the top walls. The circulating velocity will exceed 2 feet per second, which with an average period of five hours will result in a pitch of the circulating spiral of 1.75 feet giving a total length of surface travel of about seven miles.

The de-watering of activated sludge was a subject of another paper in which the various processes experimented with were discussed. The removal of water was considered under two heads known as primary and secondary removal. It was pointed out that the difficulties of de-watering are chiefly due to the physical condition of the solids which retain the water very tenaciously, to the large volume of sludge to be handled and to the importance of removing practically all the solids from the sludge.

The elasticity of the activated sludge process was pointed out in a paper under that heading. It was shown by a number of analytical results that a lengthy stoppage in aeration did not jeopardize the process. The author did not advocate stoppage of aeration in practical operation, but demonstrated by his various experiments that the process should be sufficiently elastic to stand such shocks as might occur through the operation of small works by non-technical men.

Papers were read dealing with sanitary administration and the control of malaria and yellow fever in England, the Tropics and the United States. The sanitary administration in England and Wales as considered by the author of the paper by this title, offered considerable material for thought and discussion and should be an excellent guide in establishing the basis of sanitary control in any country. The review of the duties and powers of the engineering

department of the State of Pennsylvania in the United States brought out one phase of sanitary engineering recently incorporated in the Laws of Pennsylvania, namely, the classification of the streams of that State with respect to the allowable pollution by sewage or trade wastes.

In interesting papers presented upon malaria and yellow fever control, it was pointed out that the first American control measures were exercised in Cuba in about 1901 and that to date in tropical countries and in the United States, it has been found that oiling, draining and the use of top minnows (gambusia affinis) have been the chief control measures used. It is interesting to note, however, that paris green thoroughly mixed with road dust at the rate of 1 part to 100 parts and lightly broadcasted in a light breeze is an economical larvicide for anopholes larvae. It is effective and practical where aquatic life is abundant and oiling expensive. It will not kill other mosquito larvae and, if properly applied, is harmless to aquatic life and animals that drink the treated water. With respect to yellow fever, the most effective means of control has been the covering of water barrels with a fine mesh cloth. Wells, underground cisterns, etc., have been protected by the use of gambusia afinis.

Papers upon the use of centrifugal pumps for water supply and sewage disposal, friction of sewage sludge in pipes, sewer pipe work in English practice, utilization of sewers for the disposal of snow and a number of other topics allied to the use and practices of sewerage systems were read. The study of friction losses in pipes carrying sewage sludge indicated that, for practical purposes, the friction head for 90 per cent sludge per 1000 feet of pipe line may be taken at approximately 1½ times that of water.

In a discussion of "The Combined System of Sewage With Limited Rain Water Inlet," it was pointed out by the author of the paper that the combined system could be relieved of peak loads by arranging the gullies for a limited rain water inlet and utilizing the storage capacity of the streets to hold the surplus run-off. By adopting this system, the smaller towns can save a considerable sum in the construction of their sewers.

With respect to the utilization of sewers for the disposal of snow, the interesting and practical idea of establishing the manholes at a side of the street rather than in the center so as to interfere as little as possible with traffic, was brought out. It was further urged that sewers should be used for snow removal to the fullest extent compatible with economy.

In a helpful paper on "Grit Catchers, Screens and Storm Water Tanks in Sewage Disposal Works" the author urges the discussion of the design of such devices in some standard and scientific manner.

In closing a treatise on the historical development of sewage disposal processes, the author pointed out that we are still far from a finality in sewage treatment and that the present sewage disposal methods have been in the past, and are still, matters of controversy.

The conference was primarily one dealing with sewage systems and sewage treatment practices, but the disposal of industrial wastes was also discussed. An excellent summary of the types of wastes and methods of treatment in use in the United States was presented by Mr. Harrison P. Eddy. An unusual procedure pointed out by him was the use of sodium nitrate in the treated wastes from a certain industry before their discharge, for the purpose of maintaining a suitable supply of available oxygen in the river at times of extreme low flow. Mr. Eddy pointed out that there are many single industries whose wastes are equivalent to those of a domestic city of 100,000 persons, and some of the wastes are more expensive to treat than the sewage from an equivalent population. A general discussion of the treatment of dairy, sugar factory and strawboard wastes as practiced in Holland was also presented.

In a discussion of sewage treatment in Scandinavia and Finland, the experiences with the inoculation of a sewage trickling filter bed with "achorutes viaticus" were described in detail.

A number of papers were presented dealing with house drainage, model by-laws for plumbing and regulations concerning the sanitation of dwellings. In presenting the various papers, the author of one of them stated, "In contrasting what may be conveniently designated the English with the American system of house drainage, the most prominent distinction is found in the almost universal use of the main-drain intercepting trap in the former and its general omission in the latter. Intimately connected with this is the English interposition of an 'air-break' between the liquid house wastes and the branch drains, as distinguished from the unbroken connection prevailing in America." An admirable advance in attacking these problems in a scientific way has been made by the United States Department of Commerce through a government bulletin published in July, 1923, discussing American standard plumbing regulations.

The collection, treatment and disposal of municipal wastes other than sewage was outlined as practiced in this country and abroad

by English and American engineers. Interesting details of methods of collection in use in England were outlined in a paper by Mr. J. A. Priestley. Mr. Samuel A. Greeley stated that the tendency in American practice with respect to refuse and barbage treatment is to obtain data from experimental units upon which to design the operating units. He indicated that this procedure under technical control was desirable.

It would seem from the above discussion that the first conference of sanitary engineers had forgotten the subject of water supply. A few papers, however, were presented upon this subject. The national control and allocation of water sources, as presented by Mr. Percy Griffith, offers considerable material for thought and discussion with respect to a landowner's rights in water courses, on, under or contiguous to his land. Furthermore, the author invites discussion as to the extent to which state control should cover the question of the economical use of water and pointed out conclusively that "collaboration between all interests is essential and legislation must not be regarded as a matter of party politics, but as a question of common sense administration of a valuable national asset."

Finally, the drinking water supply in the Dutch East Indies and the purification of the water supply of Leningrad, Russia, which comes from the River Neva was dealt with in an interesting manner. It was pointed out, in a discussion of the ozonification of the water of the River Neva, that the complete sterilization of drinking water by the means of excess chlorine gives a disagreeable taste which necessitates de-chlorination, whereas, with ozone used as a sterilizing agent, such excess as may remain in the water disappears rapidly and completely. In spite of this statement, however, the chief engineer of the Leningrad water works feels that from a technical point of view the only method of purifying water is by chlorination, tastes of chlorine remain only when unfiltered raw water is chlorinated and chlorination, of filtered water, with small dosages does not require de-chlorination.

THE SECRETARY OF WAR'S CONCERN OVER WATER WASTE AT CHICAGO

By John M. Goodell[1]

On March 3, 1925, the Secretary of War issued a permit for the operation of the Chicago Drainage Canal, which contains a provision illustrating a new way in which federal control may be exercised over the administration of municipal water departments. The nation-wide control exercised indirectly by the United States Public Health Service through its determination of the quality of water for passengers on interstate carriers is familiar to all water works men. The federal control now assumed by the Secretary of War is strictly local, applicable only to the City of Chicago, and is exercised to curtail the long notorious waste of water there. The Secretary does not even leave the methods of reducing waste to be determined by the City, but makes his permit for the continued operation of the Drainage Canal contingent upon the adoption by the City within six months of a project for metering 90 per cent of the water services, to be executed at the rate of 10 per cent a year.

This summary order, for it amounts to such, is so unusual in the history of water works affairs that an outline of the complicated conditions leading to it may be of interest, particularly as the water and sewerage problems of Chicago are now being considered by two Congressional committees and an international engineering board, and they seem likely to attract attention for some years to come.

The subject has two quite different aspects, which will be explained separately. The first is the development of the methods of protecting the city's water supply against pollution by sewage, and the second is the growth of serious controversies with public and private interests arising out of the operation of the Drainage Canal.

The historical feature must be kept in mind because it has had a deep and justifiable influence on the actions of the authorities of Chicago, the Sanitary District and the State of Illinois in dealing with the problems arising in connection with the City's water supply. Knowledge of this history will show the inaccuracy and unfairness of the assertion occasionally made that the Sanitary

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District has been stealing water and doing other things prejudicial to various interests.

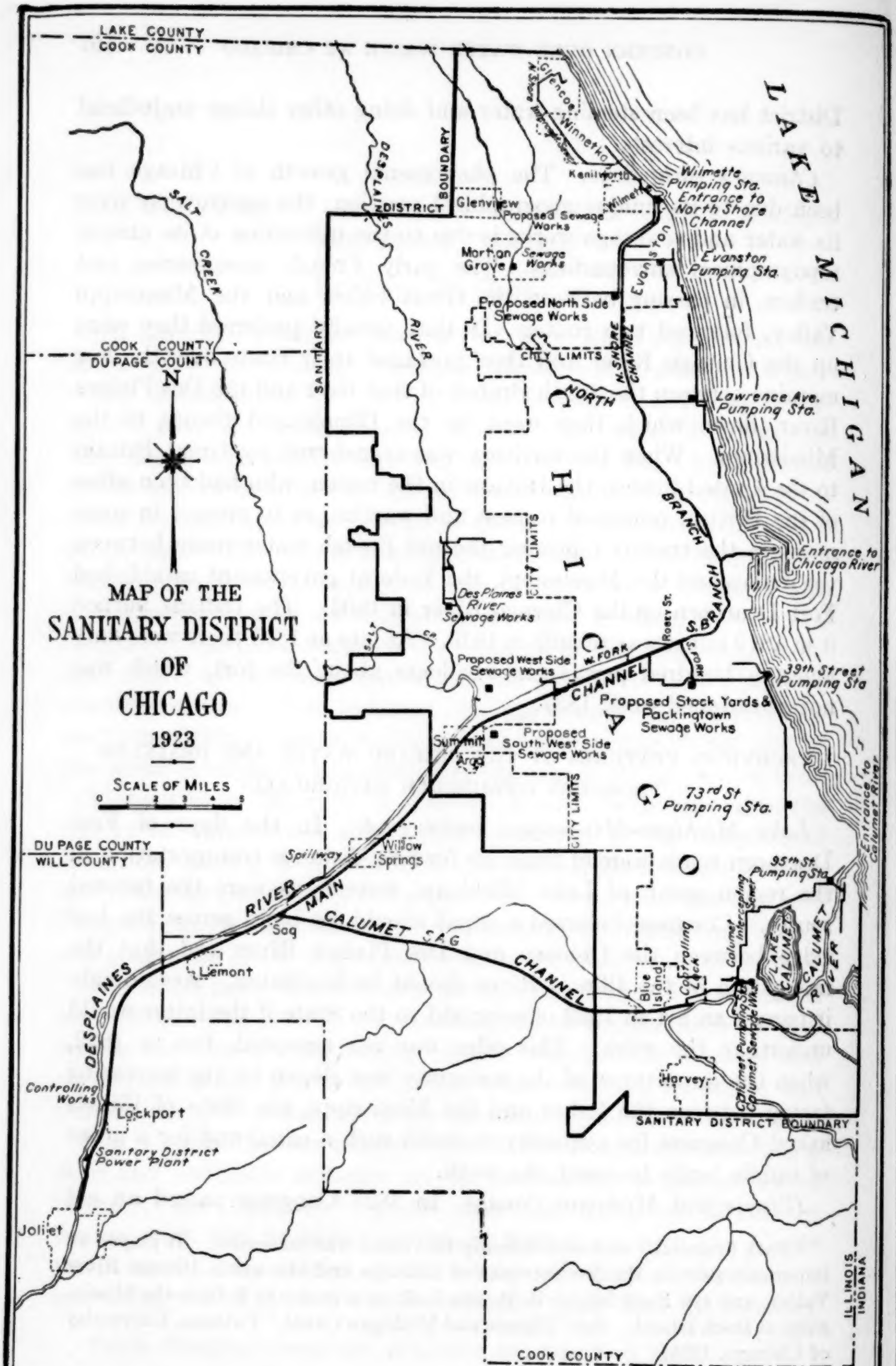
Chicago's early days. The phenomenal growth of Chicago has been due to its unique geographical position; the controversy over its water and sewerage works is due to the utilization of its unique topographical surroundings. The early French missionaries and traders, in passing between the Great Lakes and the Mississippi Valley, followed two routes. In that usually preferred they went up the Chicago River and then portaged their boats over the low moraine between the South Branch of that river and the Des Plaines River, down which they went to the Illinois and thence to the Mississippi. When the territory was transferred by Great Britain to the United States, the Indians in the region, who had been allies of the British, remained restless and warlike, so to protect in some measure the traders following the old French water route between the Lakes and the Mississippi, the Federal government established Fort Dearborn on the Chicago River in 1803. The Indians burned it in 1812 but it was rebuilt in 1816. As late as 1831 there were only about a hundred permanent residents about the fort, which was not abandoned until 1837.

TECHNICAL FEATURES OF THE CHICAGO WATER AND DRAINAGE PROBLEMS CONSIDERED HISTORICALLY

Lake Michigan-Mississippi water route. In the days of Fort Dearborn roads were of little use for long-distance transportation in the region south of Lake Michigan; waterways were the favored routes. Congress believed a canal should be built across the low ridge between the Chicago and Des Plaines River and that the navigation of the Illinois River should be facilitated. Accordingly it passed an act in 1822 offering aid to the State if the latter would undertake the work. This offer was not accepted, but in 1826, when the importance of the waterway was shown by the increasing travel between the Lakes and the Mississippi, the State of Illinois asked Congress for authority to build such a canal and for a grant of public lands to assist the work.

Illinois and Michigan Canal.[2] In 1827 Congress passed an act

[2] Both financially and economically this canal was successful. It played an important part in the development of Chicago and the whole Illinois River Valley, and the Rock Island R. R. was built as a feeder to it from the Mississippi at Rock Island. See "Illinois and Michigan Canal," Putnam, University of Chicago, 1918.



MAP OF THE
SANITARY DISTRICT
OF
CHICAGO
1923
SCALE OF MILES
LAKE COUNTY
COOK COUNTY
COOK COUNTY
DU PAGE COUNTY
DU PAGE COUNTY
WILL COUNTY
COOK COUNTY
WILL COUNTY
ILLINOIS
INDIANA
LAKE MICHIGAN
CHICAGO
SALT CREEK
DESPLAINES RIVER
SANITARY DISTRICT BOUNDARY
Glencoe
Winnetka
Kenilworth
Wilmette
Evanston
Wilmette Pumping Sta.
Entrance to North Shore Channel
Evanston Pumping Sta.
Glenview
Proposed Sewage Works
Morton Grove
Sewage Works
Proposed North Side Sewage Works
CITY LIMITS
N. SHORE CHANNEL
NORTH BRANCH
Lawrence Ave. Pumping Sta.
Entrance to Chicago River
Des Plaines River Sewage Works
Proposed West Side Sewage Works
S. BRANCH
Robey St.
W. FORK
S. FORK
CHANNEL
39th Street Pumping Sta
Proposed Stock Yards & Packingtown Sewage Works
Summit
Proposed South West Side Sewage Works
73rd St Pumping Sta.
Entrance to Calumet River
Willow Springs
Spillway
MAIN RIVER
CALUMET SAG CHANNEL
Sag
Lemont
95th St. Pumping Sta.
Calumet Intercepting Sewer
Controlling Lock
Blue Island
LAKE CALUMET
CALUMET RIVER
Calumet Pumping Sta.
Calumet Sewage Wks.
Harvey
DESPLAINES RIVER
Controlling Works
Lockport
Sanitary District Power Plant
Joliet
R. GALKE

under which the State built the Illinois and Michigan Canal, completed in 1848. It began at Bridgeport on the South Branch of the Chicago River about 5.4 miles from its mouth and ran to La Salle on the Illinois River, a distance of 97.24 miles. The water for the canal was supplied in part by raising it with a lift wheel from the Chicago River at the Bridgeport lock, and in part from the Calumet River, which fed the summit level. This canal was built for navigation purposes solely under an act of Congress which placed no restriction on its size or the quantity of water diverted by it from Lake Michigan.

Growth of City of Chicago. While this canal was being built the tide of north and south trade and emigration across the low divide south of Lake Michigan became increased by the east and west movement which was growing there rapidly. By 1837, when Chicago was incorporated, the population was estimated at 4170 and when the first careful census was taken in 1840 it was 4479. The increase in population since then, partly due to many annexations of suburbs, has been unique, as the following census returns show: 1850, 29,963; 1860, 109,263; 1870, 198,977; 1880, 503,185; 1890, 1,099,850; 1900, 1,698,575; 1910, 2,185,283; 1920, 2,701,705.

Early public works. The young trading and shipping center could not carry out public works as fast as the need for them arose. The first public well was sunk in 1831. The first water works system was built in 1840 by the Chicago Hydraulic Company and the municipal water works were started in 1851. Bored logs were used for the street pipes and some of them remained in service until the eighties. In 1855 the City began to lift itself out of the mud due to the ground level being only about 7 feet above the mean lake level, by raising the streets 5 to 15 feet and raising the buildings correspondingly, an achievement of the first order.

Even in those early days, when the primative sanitary facilities were among the "growing pains" of the future metropolis, it was realized that the water supply, necessarily taken from Lake Michigan, was becoming polluted. Typhoid fever was claiming many victims anually and there was a great fear of cholera. It was decided that the Chicago sanitary problems should be solved by some high authority and accordingly the city engineer of Boston, E. S. Chesbrough, was induced in 1855 to become engineer of the Chicago Sewerage Commission.

Mr. Chesbrough planned and supervised the construction for

Chicago of the first comprehensive system of sewers built at one time in a large American city. Most of these sewers discharged into the Chicago River. Later, when it was learned that the river water was sweeping the sewage out into the lake near the intake where the water supply was drawn, he recommended building a 5-foot tunnel extending 2 miles from shore to an intake crib which, he believed, would be far beyond the region where sewage contaminated the water. The construction of the tunnel was vigorously opposed as impracticable, but it was built in 1867 and thus established the precedent followed not only at Chicago but also at other large lake cities.

Increased diversion from Lake Michigan. From the date of the opening of the Illinois and Michigan Canal some of the sewage discharged into the Chicago River and its South Branch was lifted into the Canal by the Bridgeport pumping plant. In the late sixties, in order to increase the quantity of sewage kept out of the lake in this manner, the City obtained permission from the State to reconstruct the Canal as a gravity flow waterway. This work was finished in 1871 at an expense of $3,500,000 and resulted in a continuous flow by gravity of nearly 700 cubic feet per second from the Chicago River into the Des Plaines River. This is really the beginning of the intentional diversion of sewage-laden water by gravity through a navigable channel from the Chicago River, and consequently from Lake Michigan, in order to protect the city's water supply. It was Mr. Chesbrough who first utilized the unique topographical conditions at the south end of Lake Michigan in disposing of the city's sewage, thus adding one more distinguished achievement to the public works of Chicago. It deserves note, as indicative of the status of the engineering works of Chicago at that date, that Mr. Chesbrough received the highest honor civil engineers can bestow upon a member of their profession by his election in 1877 to the presidency of the American Society of Civil Engineers.

Late in 1871, just as the reconstruction of the Illinois and Michigan Canal was finished, Mrs. Leary's famous cow kicked over the lamp which started the great fire resulting in the destruction of 17,450 buildings including the water pumping station, and leaving nearly 100,000 persons homeless. This disaster stopped all public works until the devastated district was substantially rebuilt. It was realized, however, that the protection of the water supply against pollution and the provision of plenty of water must have attention at the

earliest possible date. The discharge of most of the city's sewage into the river had already resulted in deposits of organic sludge on its bed and their decomposition made the river notoriously offensive. When storms flooded the river some of this putrefying sludge was washed into the lake, temporarily greatly increasing the normally serious danger of contamination of the water supply.

The deepening of the Illinois and Michigan Canal somewhat increased the current in the South Branch of the Chicago River toward the head of the canal, but it had no effect on the sluggish flow and foul condition of the North Branch. Finally, the condition of the canal and the Des Plaines River also became so bad that locks and pumping equipment were again established at Bridgeport, at the head of the canal, and enough water was pumped into the canal to increase its flow to 1000 cubic feet per second, all it would carry. The pumping was resumed in 1883. In 1885 a large conduit was constructed from the lake front under Fullerton Avenue to the North Branch, in order to produce a circulation in the latter.

Chicago River at its worst. These works accomplished little to prevent sewage being carried by the Chicago River during rains into the lake and polluting the water supply. The principle was correct, but the capacity was inadequate. The conditions rapidly became so bad, on account of the rapid growth of the population and the increase in industrial sewage, that they are now hardly believable. They are described in the following extracts from a statement by Geo. M. Wisner, formerly chief engieer and now consulting engineer of the Sanitary District of Chicago, to the Rivers and Harbors Committee, United State House of Representatives, on May 27, 1924:

> There were floating islands of sewage sludge in the main river, held up by the generation of gases, generated on the inside of it, and as the gas would break through sometimes these islands, 20 or 25 feet across, would sink, and then would come up a big bubble of dirty, stinking mud. This in the heart of a big city! The North Branch got so bad that it caught on fire. There was so much of waste products being allowed to escape from the gas company's plant which had floated upon the surface of the water that it caught on fire; and the peculiar thing of watching a fire engine coming to put out a river that was burning was something to remember. And also chickens crossed the river on this sludge; chickens could often walk across on sewage sludge in certain parts of the river.

Drainage and Water Supply Commission. About 1885 Chicago had recovered from the 1871 fire, and as typhoid fever was causing many deaths, 74.6 per 100,000 population in that year, it was de-

cided that the water supply and sewage disposal problems must be studied and the existing conditions improved greatly. Accordingly, early in 1886, the City Council created a drainage and water supply commission of engineers to report on the increase in the water supply, its protection from pollution, and the best remedy for the unsatisfactory conditions due to the existing facilities for sewage disposal. This commission consisted of Samuel G. Artingstall, then city engineer, Benezette Williams and Rudolph Hering, the last-named being the chief engineer. Their report, dated January, 1887, has long been regarded as a notable engineering document.

They reported that the city water works were being operated at their full capacity and they recommended the construction of another pumping station and intake tunnel taking water at a point about 2 miles from the shore. There was no question that the lake was the only source of supply and, therefore, "both its pollution and the objectionable condition of the rivers should be prevented by a better disposition of the sewage."

The greater part of the report relates to the sewage disposal problem. After explaining the impracticability of discharging the sewage into the lake or treating it upon land by any method then known, the commission recommended diluting the sewage with lake water at the rate of 4 cubic feet per second per 1000 persons, and conducting the mixed sewage and water through a large new channel from the South Branch of the Chicago River to the Des Plaines River at Joliet. The water was to flow from Lake Michigan through the Chicago River to its South Branch and thence to the head of the new channel. To prevent floods from reversing this flow, it was decided that the main channel should be large enough to carry 10,000 cubic feet per second, the flood run off of the Chicago River water shed, with a current of 3 feet per second. This volume of water was reported as adequate to dilute to an unobjectionable condition the sewage of 2,500,000 persons, a population which the city and its suburbs would have, it was estimated, somewhere between 1905 and 1915. It is worth mentioning that the population of the Sanitary District reached this figure in 1913.

Creation of Sanitary District. The report was submitted to the State Health Department and the State Legislature. Dr. John H. Rauch, secretary of the Health Department, after a study of the conditions in the Des Plaines River, reported in favor of the project. In the Legislature, however, the practicability of using the pro-

posed drainage channel as an inland waterway seems to have been more effective in winning support for the project than were the sanitation necessities of Chicago and its suburbs. After long discussion and investigation the Legislature passed a joint resolution on May 28, 1889, to the effect "that it is the policy of the State of Illinois to procure the construction of a waterway of the greatest practicable depth and usefulness for navigation from Lake Michigan via the Des Plaines and Illinois Rivers to the Mississippi River and to encourage the construction of feeders thereto of like proportions and usefulness."

The following day the Legislature passed a law authorizing the formation of sanitary districts by associating neighboring communities in the same county for the purpose of building joint main drainage works. It required in the main channel of such a district a continuous flow of $3\frac{1}{3}$ cubic feet per second per 1000 population. This is less than was recommended by Hering, Williams and Artingstall, and was apparently adopted after a consideration of all the evidence which Hering and Rauch could obtain at that time. The total minimum flow was fixed at 300,000 cubic feet per minute with a current not exceeding 3 miles per hour. Where the bed of the channel was in rock the depth of water was to be at least 18 feet, although in earth it need not exceed 14 feet. The rock cuts were required to have a capacity of 600,000 cubic feet per minute with a current not over 3 miles per hour, and have a bottom width not less than 160 feet. It is apparent that the minimum dimensions of the channel were fixed by the Legislature with a view to its navigability.

The only reference in the act to water works is a provision by which a city or town in the district owning a water works plant "shall" furnish water to any other city or town in the district, which has no water works, at the same meter rates charged its local consumers.

The Sanitary District of Chicago. The Sanitary District of Chicago was organized in 1889 under this law and, at the beginning, had an area of 185 square miles and a population of 1,140,000. Its growth since then has been as follows:

	YEAR				
	1890	1900	1910	1920	1924
Population	1,149,758	1,775,882	2,311,810	2,986,000	3,280,000
Area, square miles	185.00	185.00	358.10	395.51	437.39

It is unnecessary to list here the various works[3] built by the Sanitary District to dispose of the sewage by dilution. Their cost amounted late in 1923 to $97,600,000 and $11,400,000 had been spent in addition for maintenance and operation.

SEWAGE TREATMENT

Following the opening of the Drainage Canal on January 17, 1900, there was a great improvement in the quality of Chicago's water supply. Unfortunately the capacity of these dilution works to dispose of the sewage without causing offense was reached earlier than the authors of the report of 1887 anticipated, because of the great increase in the quantity of industrial wastes of an organic character, equivalent to municipal sewage in its effect on the streams receiving it. Trouble arose, also, because the flow in the Drainage Channel was not equal to that required by the State act of 1889, on account of the controversies with the Secretary of War which

TABLE 1

Actual flow in the Chicago main drainage channel and that required by Illinois Statute for the population served

YEAR	POPULATION	FLOW		YEAR	POPULATION	FLOW	
		Legal	Actual			Legal	Actual
		cu. ft./sec.	*cu. ft./sec.*			*cu. ft./sec.*	*cu. ft./sec.*
1900	1,640,000	5,467	2,990	1913	2,509,000	8,363	7,839
1901	1,688,000	5,627	4,046	1914	2,589,000	8,630	7,815
1902	1,736,000	5,787	4,302	1915	2,652,000	8,840	7,738
1903	1,934,000	6,447	4,971	1916	2,716,000	9,053	8,200
1904	1,985,000	6,617	4,793	1917	2,782,000	9,273	8,726
1905	2,035,000	6,783	4,480	1918	2,846,000	9,487	8,826
1906	2,090,000	6,967	4,473	1919	2,916,000	9,720	8,595
1907	2,144,000	7,147	5,116	1920	2,986,000	9,953	8,346
1908	2,195,000	7,317	6,443	1921	3,063,000	10,210	8,355
1909	2,250,000	7,500	6,495	1922	3,143,000	10,477	8,858
1910	2,308,000	7,693	6,833	1923	3,214,000	10,713	8,348
1911	2,370,000	7,900	6,896	1924	3,284,000	10,947	9,465
1912	2,432,000	8,107	6,938				

[3] A brief description of these works is given in "Engineering Facts concerning the Sanitary District of Chicago," which can probably be procured from Edward J. Kelly, Chief Engineer of the District, 910 South Michigan Avenue.

will be explained later. This point is so important that the actual flow and that required by the Illinois statute are given in table 1.

Sewage treatment investigations. When Mr. Wisner was promoted to the position of chief engineer of the District in 1907 he was convinced that it was necessary to begin preparing plans for treating at least part of the sewage at an early date, so as to reduce the quantity of diluting water required for a given quantity of sewage. In 1909 he secured the assistance of Langdon Pearse, who has since then been in direct charge of the sanitary research work of the District. Over $750,000 has been spent since then in research, including river surveys, laboratory investigation, and work at four testing stations. The Sanitary District has spent $35,000,000 for treatment works with the intercepting sewers leading to them, and the City of Chicago has also spent about $4,000,000 for sewage pumping stations and intercepting sewers. It is difficult to reconcile the criticism that the Sanitary District has been dilatory in treating the sewage before it is diluted in the Drainage Canal, with these facts of what it has already spent for such work.

The first experimental station treated the sewage from a population of 270,000 on an area of 22 square miles, with few industries. This station was operated during 1909–1914, inclusive.

The second station was established to determine the best method of treating packing house sewage. It was operated during 1912–1918, inclusive, and in connection with the experiments the quantity and character of the sewage from every packing house in the District was determined in 1911. In 1917 the sewage from 31 packing houses was again gauged and analyzed.

Although the tannery situation was studied continuously for ten years after 1912, the third testing station, to study the sewage from the twenty tanneries and ten wool pulling or scouring plants along the North Branch, was not built until 1919. It was operated until 1923.

The works of the Corn Products Refining Company at Argo, where over 75,000 bushels of corn are converted daily into glucose and starch, furnish a large quantity of objectionable sewage. The fourth testing station, established to determine the best method of treating this sewage, has been busy on the work since it was opened in 1921.

In connection with this experimental research to determine the character of the four main classes of sewage to be treated, the Sani-

tary District and the United States Public Health Service began in 1921 a joint examination of the conditions in the Des Plaines and Illinois Rivers. This furnished valuable data for determining the extent to which sewage must be treated in order to prevent the diluted effluents from the treatment works causing offensive conditions in these rivers.

TABLE 2

Works comprised in the sewage treatment projects of the Sanitary District of Chicago

TREATMENT PLANT	AREA SERVED, SQUARE MILES	TYPE OF PLANT	YEAR OPENED	COMMENTS
Des Plaines River*	18.5	Activated sludge	1922	Now overloaded, more tanks needed
Calumet*	42.5	Imhoff tanks; trickling filters later	1922	
North Side	62.0	Activated sludge		Under contract
Industrial wastes:†				Suits instituted to force industries to pay part of cost
Argo starch works		Trickling filters		
Packing houses		Activated sludge		
West Side	57.5	Imhoff tanks, trickling filters later		
Southwest Side	59.0	Imhoff tanks		
Miscellaneous		Imhoff tanks	1914	Small plants and sewers for isolated towns
Related works				Bridges, roads, etc.

* Many large-scale experimental studies have been carried on at these plants, including trials of trickling filters and of the activated sludge process at the Calumet works.

† The Engineering Board of Review reported that 29 per cent of the total load on the dilution system of disposal was due to these wastes.

Program for sewage treatment. As a result of the investigations begun in 1909 and still continuing, Mr. Wisner reported in 1911 that plans for beginning to treat a large part of the sewage of the District should be started at once. In 1913 advice regarding treat-

ment methods was sought from Geo. W. Fuller, Allen Hazen, F. P. Stearns and Asa E. Phillips. In that year a site on 52d Avenue was bought for treatment works for which plans were prepared, but work was stopped by the agitation against the project conducted by the advocates of converting the Drainage Canal into a deep ship canal.

In 1914 Mr. Wisner again recommended the immediate preparation of plans for sewage treatment on a large scale, in that year the District's first treatment plant was opened. This was at Morton Grove and was a small plant with an Imhoff tank and trickling filters. The World War checked normal progress in such matters, but in 1919 a plan for treatment works calling for an expenditure of $125,000,000 was adopted. In 1921 the Illinois Legislature passed an act requiring the construction of these works to proceed at such a rate that, beginning with 1925, the sewage of at least 300,000 additional persons per year would be treated, until the various works were able to handle the sewage of a population of 1,800,000.

The works as planned and now partly constructed fall into eight groups, as outlined in table 2. The plans were submitted in September, 1924, to an Engineering Board of Review composed of 28 engineers with E. E. Haskell as honorary chairman, Geo. W. Fuller as chairman and Paul H. Norcross as secretary. It reported a series of recommendations, findings and conclusions on December 20, 1924, from which the following extracts have been taken:

27. The plan for sanitary improvements authorized in 1889 and executed at a capital cost to date of approximately $100,000,000 was not only sound but the best that could have been devised. It has been a success. The typhoid fever death rate has been reduced from a maximum of 174 per 100,000 inhabitants in 1891 to less than 2 per 100,000 in 1917; since then it has remained consistently below 2, with an average of less than 1.2 per 100,000 inhabitants.

31. The population within the Sanitary District is now 3,300,000, the sewage from which, together with that from the stockyards, packing houses, and other large industrial plants, is equivalent to that from a population of 4,800,000. At the minimum rate of dilution prescribed by the Illinois State law the flow required through the Main Drainage Canal at Lockport would be 11,000 cubic feet per second for the actual population and 16,000 for the equivalent population.[4] From the State of Indiana, the sewage and industrial

[4] The equivalent population is the sum of the actual population and the population furnishing sewage equivalent to the industrial sewage in the load it places on treatment works and dilution systems.

wastes of a rapidly increasing population, numbering at present about 170,000 people, reach the Drainage Canal from the Calumet River area.

32. Sewage disposal by dilution continues to be good practice within the limitations of available volume of water. In recent years practicable artificial methods of sewage treatment have been developed, which are capable of purifying, to a high degree, large volumes of sewage. At present a number of treatment plants have already been built or are under construction by the Sanitary District of Chicago, which, when completed in the next two or three years, will treat the sewage of more than 1,000,000 people. No other city in the United States is treating the sewage of so large a population.

33. The District's present program, subject to modifications set forth in the detailed report, should be completed as rapidly as financial conditions permit, and thereafter an additional program should be begun, involving a further expenditure of at least $35,000,000 to provide complete treatment of the dry weather sewage.

34. This sewage treatment program, in conjunction with works now built or under construction, supplements dilution, is sound, and should produce satisfactory conditions in the Des Plaines-Illinois River. Sewage treatment would be facilitated by a reduction of Chicago's present excessive water consumption.

35. To abandon the Main Drainage Canal and again discharge the sewage into Lake Michigan, even though the most effective means be provided for purification of the sewage and the water supply, would be a serious step backward in sanitation. Failure to take reasonable and proper advantage of natural and artificial conditions would not be justified.

Present canal and river conditions. While the plans of the Sanitary District were endorsed by the Engineering Board of Review, it gave careful attention to the conditions in the Chicago River, the Main Drainage Channel, and the Des Plaines-Illinois River and made some positive statements concerning the quantity of diluting water required to produce satisfactory conditions in those waterways, part of which are summarized here on account of their importance.[5]

Water required to prevent the Chicago River from flowing into the Lake. If the diversion is limited to 4167 cubic feet per second, the quantity permitted by the Secretary of War down to March 3, 1925, there would probably be seven or eight times a year when storms on the watershed of the river would cause it to flow into the Lake. As the building on the watershed increases, the floods will increase. With a diversion of 5000 second-feet, the river current would be toward the Lake five or six times a year; with 7500 second-feet, three or four times a year; with 9500 second-feet, about once a year.

[5] Part 2 of the report of the Engineering Board of Review was submitted January 23, 1925, and contains a review of the technical bases for the recommendations of the Board in Part 1 of its report, submitted December 26, 1924. Copies of these important documents can be obtained from the Chief Engineer of the Sanitary District, Edward J. Kelly.

The lake level at Chicago will sometimes fall 6 inches in an hour as a result of winds or a barometrical change. With the canal carrying 4167 second-feet at the beginning of such a sudden drop, the upper 14 miles of the canal and river would be above lake level. This would cause a flow into the lake. It requires 8 hours for a change in the position of the regulating works at Lockport to have an appreciable effect on the Chicago River, and 24 hours to have full effect.

With a diversion of 4167 second-feet the water supply of the city would be in constant danger of pollution, and this danger decreases as the quantity of water diverted from the lake increases.

The combined sewerage system of Chicago is the best for several reasons. The intercepting sewers will carry to the treatment plants all the dry-weather sewage and a quantity of storm water equal to half of the dry-weather sewage. Heavy storms will cause the combined sewers to carry a mixture of sewage with a quantity of storm water several times its volume. It is both physically and financially impossible to build intercepting sewers, pumping stations and treatment plants to care for all this mixed sewage and runoff from heavy storms, and the excess above 150 per cent of the average dry-weather flow must be discharged into the river. If the current in the river is reversed during such periods, sewage will be swept in to the lake and the water supply will be in danger of contamination.

Conditions in Chicago River. Substantial deposits of sewage sludge occur in the river and their putrefaction during the summer causes disagreeable odors and the appearance of masses of scum on the surface.

Conditions in Main Canal. The deposits of sewage sludge are greatest in the large earth section and the forebay of the Lockport power house. Measurements made in 1911 and repeated in 1924 show that the progressive increase in the current has during 1911–1924 washed away part of deposits except in the forebay, where they have increased. The canal water at Lockport is nearly free from odor in winter but has a distinct sewage odor in summer and sludge floats on the surface, as in the Chicago River. Experience shows that a current of 1.7 feet per second is necessary to prevent the deposit of sewage solids on the bottom of the canal.

Conditions in the Des Plaines-Illinois River. Between Joliet and Peoria there are deposits of sewage sludge except in short stretches where the flow is turbulent. Below Peoria they are less extensive but increasing annually, partly due to sewage and industrial wastes received from local communities, the two combined being now equivalent to the ordinary sewage of 1,200,000 persons. The State is now improving a part of the river to give a 9-foot navigable channel from Lockport to Utica. This work will increase the tendency for deposits to form on the river bed.

Except where deposits of sludge are exposed by low water, polluted streams do not give off putrid odors so long as there is oxygen dissolved in the water. The quantity of dissolved oxygen is taken, therefore, as an indicator of the liability of a stream to give off offensive odors. Investigations in July and August, 1922, months when objectionable conditions are most likely to occur, gave the following results:

In summer the supply of dissolved oxygen in the diluting water from Lake

Michigan is entirely used up by biological action during the 24 hours required to flow 36 miles to Lockport. Practically no oxygen is absorbed in the passage of the water through the water wheels of the power plant at this point. In the 8-mile turbulent stretch of the river immediately below, oxygen is rapidly absorbed from the air. This new supply, in addition to that furnished by continuous but less rapid reaeration during the flow of the river, is greatly depleted within 10 miles and continues low or exhausted until the dam at Marseilles is reached 30 miles farther down stream. Here again oxygen is absorbed rapidly during the passage of the water over the dam, but biological activity is so great that the oxygen is soon materially depleted, if not exhausted, on the way to Henry where a limited fresh supply is absorbed in passing over a submerged dam. Depletion continues for some distance, but while passing 15 miles or more through Peoria Lake a large new supply of oxygen is obtained due to relatively long exposure to the air, aided by the action of the wind, and to oxygen-producing organisms. Notwithstanding the fact that a large quantity of sewage and industrial wastes is introduced into the lower river at various points beginning at the city of Peoria, equivalent to the sewage from a population of 1,000,000, the process of purification continues, and at Kampsville, 296 miles from Lake Michigan, the water has become practically stable and the sewage of the Sanitary District has become well purified.

Water needed to prevent offensive conditions in the Des Plaines-Illinois River. A study of the canal system and the Des Plaines-Illinois River, taking into account the physical conditions, the time of flow, the effect of reaeration and deposits of sewage solids, the composition of sewage, industrial wastes, and diluting water and other determinable factors, indicates that a flow of from 15,000 to 20,000 cubic feet per second at Lockport is necessary to prevent offensive conditions along the river at the present time, in summer. These flows correspond to 5 and 6.7 cubic feet per second per 1000 human population or to 3.3 and 4.5 cubic feet per 1000 equivalent population. It is certain that a flow of 10,000 second-feet is insufficient to prevent offensive conditions in summer.

Much less water is necessary to prevent exhaustion of dissolved oxygen during the winter and spring than in the summer and fall, because in the colder period there is about 50 per cent more dissolved oxygen in the lake water; the sewage contains a larger amount of dissolved oxygen; the rate at which the oxygen demand of the sewage is exerted is materially less; the oxygen demand exerted by the sludge deposits in the canal system and river is much smaller; the flows of the tributary streams are much greater, and there is more dissolved oxygen in the water of the tributaries.

It is estimated that in 1945 the human population will be 4,785,000 and the industrial wastes-equivalent population 2,000,000. Prior to 1945, complete treatment will be afforded by all except the West Side and the Southwest Side plants where Imhoff tanks will be provided. It is estimated that the oxygen demand at these two plants will be reduced 33⅓ per cent. The oxygen demand of ordinary sewage unaffected by industrial wastes will be reduced by complete treatment by either the activated sludge process or by Imhoff tanks and trickling filters.

As the treatment projects are completed, the quantity of sewage solids depositing in the canal system and river will decrease. With this decrease, there will be a decrease in the oxygen demand by the deposits and those already existing will gradually be converted into stable, unoffensive material. After 1945 it is certain that reaeration will offset the effect of any remaining deposits. By that date a total diversion of 10,000 second-feet from Lake Michigan in summer will be sufficient to satisfy the oxygen demand of the effluents from the treatment plants. This flow will be equivalent to 2.1 second-feet per 1000 combined human and industrial wastes-equivalent population.

It is estimated that in 1955 the human population will be 5,500,000 and the industrial wastes-equivalent population 2,200,000, or a total of 7,700,000. By that date there should be a complete treatment of all sewage and industrial wastes, and under such conditions a total flow of 5400 second-feet at Lockport will satisfy the oxygen demand of the effluents. This is about 0.7 second-foot per 1000 combined human and wastes-equivalent population.

Condition of the Calumet River. The Calumet-Sag Canal was designed for a flow of 2000 second-feet. Owing to the inadequate connection between it and the lower improved part of the Grand Calumet River, its capacity has not been utilized and during 1924 an average flow of only 750 second-feet could be maintained. The Grand Calumet and the Little Calumet, which join to form what is usually termed the Calumet, have a watershed of 689 square miles, exclusive of the strip tributary to the Calumet-Sag Canal, and the flood discharge is likely to reach 4500 second-feet once a year, 6300 second-feet once in five years, and 7000 second-feet once in ten years. The river is polluted with sewage and industrial wastes, part of them originating in Indiana. With an average of but 750 second-feet diverted into the Calumet-Sag Canal, the river carries sewage into Lake Michigan frequently. During 1924 observations of the flow of the river were made on 253 days, and on 115 days the river flowed into the lake, this condition sometimes lasting several consecutive days.

Sewage discharged by the Calumet River into the lake in 1923 is believed to have been the cause of a mild epidemic of typhoid fever in the district supplied with water from the 68th Street crib, 3½ miles north of the mouth of that river. Winds have been observed to carry the sewage-polluted water north to the Dunne intake crib in the same vicinity.

CONTROVERSIES ARISING OUT OF THE OPERATION OF THE DILUTION WORKS

What has been said up to this point outlined the method by which Chicago has protected her water supply successfully by taking advantage of the unique topographical conditions at the south end of Lake Michigan. The recent unanimous approval of the dilution system of sewage disposal by the 28 members of the Engineering Board of Review and that Board's comments on the operation of the system have been reviewed in detail to show how unwarranted

is the charge that the dilution works are obsolete or imperfect, and that sewage treatment works have not been carried forward steadily. A statement of the results of the inability of the Sanitary District to operate the system as required by the Illinois law has been given and the reasons for this failure will now be explained.

Currents in the Chicago River. By the ordinance of 1787 establishing the Northwest Territory, the State of Illinois was given full jurisdiction over all navigable waters within its borders, subject only to the power of the Federal Government to enact such legislation and to make such regulations as relate to interstate commerce (Economy Light and Power Co. v. United States, 256 U. S. 113).

On September 19, 1890, Congress first enacted a law specifying any general policy in the exercise of its rights over navigable waterways. In Section 10 of the rivers and harbors act of that year, the creation of any obstruction, not officially authorized by law, to the navigable capacity of any waters under the jurisdiction of the United States was prohibited.

On April 21, 1891, the Sanitary District adopted a resolution to undertake the improvement of the Chicago River, sending a certified copy of it to the Secretary of War. On June 16, 1896, the Sanitary District requested the Secretary of War to permit the beginning of the improvements. The application was granted July 3, 1896, on the understanding that detail plans of each feature of the improvements must have the approval of the Secretary of War before work began, that the approval did not also approve the creation of a current in the river by the drainage canal, that it did not approve any obstruction to navigation during and after the work, and that the United States should not be put to any expense by reason of the work. Under a number of later special permits the river was widened and deepened and bascule bridges substitute for center pier swing bridges.

On March 3, 1899, Congress passed, as part of the rivers and harbors act of that year, the stature under which the Secretary of War has since exercised supervision over navigable waters. The drainage canal was nearly ready for operation at the time. The act prohibits the creation of any obstruction, not affirmatively authorized by Congress, to the navigable capacity of any waters of the United States, and the building of any wharf or other structure outside established harbor lines except with the approval of the Chief of Engineers and authorization by the Secretary of War,

and any alteration or modification of navigable waters except with similar approval and authorization.

On May 8, 1899, a permit was granted by the Secretary of War for opening the main drainage channel and causing a reversal of flow in the Chicago River, subject to the following conditions: (1) The Secretary of War intended to submit the questions raised by the operation of the drainage canal to Congress and the permit was subject to later action by Congress. (2) The Secretary of War reserved the right to modify the rates of flow in the river to such an extent as might be demanded by navigation and property interests. (3) The Sanitary District assumed all responsibility for damage to property and navigation resulting from currents in the river due to the drainage canal. This original permit placed no limitation on the flow through the river into the canal, except as stated.

On June 20, 1900, after the drainage canal had been in operation five months, the District Engineer Officer reported as follows to the Chief of Engineers:

> If I have not overestimated pilot skill and considering the immense benefit of the drainage canal to the City of Chicago since its opening only a few months ago, I recommend that no restrictions be placed upon the legal requirements of flow into the sanitary canal unless it should be found absolutely necessary to do so. The engineer department, the City of Chicago, and the Sanitary District are of one mind as to the need of improving Chicago River and are coöperating heartily to that end, and large sums of money are appropriated and being expended judiciously by each for the objects in view. The interests of navigation are not only being protected but are being advanced sooner than could be hoped for in the usual course.

On April 9, 1901, the Secretary of War ordered the maximum flow through the river reduced to 200,000 cubic feet per minute because, the order stated, "it is alleged by various commercial and navigation interests that the present discharge from the river into the drainage canal sometimes exceeds 300,000 cubic feet per minute, causing a velocity of nearly 3 miles per hour, which greatly endangers navigation in the present condition of the river."

After two modifications of this permit during 1901, on January 17, 1903, the Secretary of War authorized a flow of 350,000 cubic feet per minute until March 31 of that year, during the closed season for navigation. This was a larger diversion of water than was then required under the State law, but since March 31, 1903, the per-

mitted diversion has been 250,000 cubic feet per minute or 4167 cubic feet per second, until March, 1925, as will be stated later.

All of these restrictions on the flow of the river toward the drainage canal were imposed in the interest of river navigation and river front property. The Sanitary District continued its work of improving the navigability of the river in the expectation that when conditions were substantially better than those when the rate was fixed at 4167 second-feet, the Secretary of War would permit a larger flow than that through the river. However, no such change was made because another condition, the effect of the operation of the canal on the lake levels, came to the front.

The Canal's influence on Lake levels. So much has been written officially on this subject that it is impracticable even to list the reports here. The active opposition to the canal on the ground that its operation lowered lake levels and thus affected shipping interests in the Great Lakes and St. Lawrence River started in 1896, when Canada invited the United States to take part in a joint investigation of the facts. Action on this invitation was delayed until June 13, 1902, when the International Waterways Commission was authorized in the rivers and harbors act of that year. The reports issued by this commission are highly regarded.

On April 24, 1899, the District Engineer at Chicago reported to the Chief of Engineers that the discharge of 300,000 cubic feet per minute through the Chicago River would tend to lower the levels of Lakes Michigan, Huron and Erie from 3 to 6 inches.

On March 14, 1907, the Secretary of War refused to permit a diversion of water from Lake Michigan through the Calumet River and Calumet-Sag canal to the main drainage canal, on the ground that the diversion would affect lake levels and the subject was one for Congress to pass upon.

Conferences were held with the President and the Secretary of War to ascertain what could be done in view of the clash of authority between the State and Federal Governments. The Sanitary District wished to obey the Secretary of War, but it had to take its orders from its immediate superior, the State of Illinois. It was accordingly decided that a friendly suit should be brought against the Sanitary District by the United States Department of Justice to determine the relative jurisdictions of the State and the United States in the matter, since there were involved the sanitary measures and waterway improvements carried on by the State and its agencies

and the control over the waterways so far as they were navigable by the War Department. Had Congress ever acted comprehensively and equitably on the recommendations of that Department for legislation considering all features of the diversion at Chicago, this suit would have been unnecessary. In order to afford grounds for the suit, the Sanitary District passed a resolution on September 18, 1907, to construct the Calumet-Sag Canal although the Secretary of War had refused permission for its operation. On March 23, 1908, the Federal Government brought its first suit in equity, which had not been settled when the canal was opened.

On June 27, 1910, the Sanitary District applied for a permit to construct this canal, which the Secretary of War granted on June 30, 1910, provided the total diversion from Lake Michigan through the Chicago and Calumet Rivers did not exceed 4,167 second-feet and with the understanding that the Secretary of War was to submit the questions involved by the diversion to Congress. In this year, on June 25, Congress acted indirectly on the subject by authorizing in the rivers and harbors act an investigation of the effect of diversions of water on lake levels and measures for remedying any undesirable effects.

By 1912 the improvement of the Chicago River had been carried so far that the diversion of 10,000 second-feet through it and the drainage channel would, it was believed, cause no obstacle to navigation in the river. On February 15 the Sanitary District applied to the Secretary of War for a permit for this diversion; Canada and the Lake Carriers Association opposed it. On January 8, 1913, the Secretary of War refused the permit on the ground that the diversion would affect lake navigation injuriously and Congress alone could authorize it, particularly in view of the recently signed treaty with Great Britain regarding boundary waters. The Sanitary District had always held that this treaty did not prohibit a diversion of 10,000 second-feet at Chicago and the documentary evidence of the proceedings leading up to the signing of the treaty indicates that the District's view is correct, the diversion having been accepted as a settled fact by both the Canadian and American commissioners upon whose recommendations the terms of the treaty were drawn. The diversion is not specifically mentioned in the treaty because, according to Elihu Root, then Secretary of State, he would not permit any reference to Lake Michigan in the treaty because it was not a boundary water, lying wholly in the United States.

On October 6, 1913, another suit in equity was brought by the United States against the Sanitary District to cover points not at issue in the first suit. The two suits were thereafter tried together by mutual agreement of the parties, and the case was submitted to the District Judge on February 15, 1915.

In 1913 the engineering board appointed under the 1910 act of Congress, previously mentioned, made a report which was reviewed by the United States Board of Engineers on Rivers and Harbors, Gen. Wm. S. Black being its senior member. Its report said:

> The Board believes that the total volume of water to be diverted from the natural discharge channels of the lakes should be definitely fixed by Congress; that a project with estimate of cost for works necessary to compensate for such diversion should be prepared to the satisfaction of the Chief of Engineers and the Secretary of War before any diversion is made beyond that at present existing, and the State of Illinois shall transfer to the Secretary of War the funds necessary for such works as given by the approved estimate of cost; that the works shall be built by the United States with the funds so provided, and that the control and maintenance shall be in and at the cost of the United States.

The outbreak of the World War and its international consequences gradually slowed up progress on large public works, but by 1917 the Sanitary District had worked out what seemed a practicable solution of the dilemma due to the conflicting orders given it by the State and the War Department. On June 30 of that year Congress also acted on the many recommendations made to it on account of the conditions at Chicago to the extent of directing the Secretary of War to make a thorough investigation of "the entire subject of water diversion from the Great Lakes and the Niagara River, including navigation, sanitation and power purposes." This was carried out by Col. J. G. Warren, whose report is one of the most valuable documents on the subject.

On January 5, 1918, the Sanitary District adopted a resolution offering to pay the reasonable cost of compensating works, to be built by the United States, for restoring normal lake levels by the amount due to a diversion of 12,000 second-feet at Chicago, if Congress would authorize that diversion.

In January, 1918, Congressman Gallagher of Illinois introduced a bill to carry out the recommendations of the engineering board of June 25, 1910. This bill never came to vote because of Canadian opposition due in part to alleged heavy lowering of water levels

in Montreal Harbor by the existing diversion at Chicago. The Sanitary District engaged F. C. Shenehon about this time to prepare plans for compensating works for the consideration of the Chief of Engineers, as suggested by the engineering board of June 25, 1910.

As no action of importance had been taken by Congress on the many recommendations by the Secretary of War that it should determine the policy to be followed, the United States District Judge before whom the equity suits had been tried rendered an oral opinion on June 19, 1920, directing a decree to be drawn enjoining the Sanitary District from diverting over 4167 second-feet from Lake Michigan. On July 12, 1920, the Sanitary District filed a motion in the District Court asking that the injunction be modified to permit a diversion of 10,000 second-feet providing that the District agreed to pay for compensating works which would nullify the effect of the diversion on lake levels. On June 18, 1923, the motion was denied, but the effect of the injunction was suspended pending the decision of the Supreme Court to which an appeal was taken.

On January 5, 1925, the Supreme Court decided that the authority of the United States to remove obstructions to navigation was superior to that of the States to provide for the public health of their inhabitants by utilizing navigable waters for the purpose. The court ruled that the diversion of 10,000 second-feet would lower lake levels to an amount bringing the diversion under the rivers and harbors acts of 1899, even though this diversion was ordered by an Illinois statute. The 1827 act of Congress authorizing and subsidizing the construction of the Illinois and Michigan canal "vested no irrevocable discretion in the State with regard to the amount of water to be withdrawn from the lake. . . . . This suit is not for the purpose of doing away with the channel, which the United States, we have no doubt, would be most unwilling to see closed, but solely for the purpose of limiting the amount of water to be taken through it from Lake Michigan." The degree for an injunction was affirmed, to go into effect in sixty days, "without prejudice to any permit that may be issued by the Secretary of War according to law."

If there were any truth in the charge so often made that the Sanitary District had been stealing water from the Great Lakes or had been breaking the federal laws, the United States Supreme Court

would surely have indicated it in its decision. Nothing of the sort is said by the court, but, on the contrary, it indicates very clearly that lack of appropriate legislation by Congress resulted in a conflict of authority between State and United States and rendered it impossible for the Sanitary District and the Secretary of War to reach any permanent agreement.

Report on Lake levels of Engineering Board of Review. The facts regarding the lake levels were summarized in Part II of the report of the Engineering Board of Review, submitted in January, 1925, as follows:

If an annual average flow of 10,000 cubic feet per second passes from Lake Michigan into the Drainage Canal, and no provisions are made to hold back part of the storm water entering the Lakes for discharge during dry periods, then this diversion will eventually produce a small permanent lowering of all Lakes except Superior. The lowering by reason of the diversion will be greatest in Lake Michigan-Huron, where it will never exceed 6 inches. To this extent it will affect the draft to which the largest lake vessels can be loaded, unless measures are taken to restore the natural lake level. A like result follows every similar diversion of lake water.

The permanent effect of the Drainage Canal on lake levels has been ascertained accurately by the Corps of Engineers, U. S. A. The effect of regulating works on lake levels has been definitely demonstrated by such works at the foot of Lake Superior. If the levels of the other Lakes are likewise regulated, the effect on these levels of the diversion of 10,000 cubic feet per second at Chicago becomes unimportant. This regulation of the lake levels has long been advocated, and works to accomplish it will probably be undertaken before long, no matter what quantity of water is diverted through the Drainage Canal. The cost of the works for this necessary regulation of the lake levels is affected very little by the diversion of 10,000 cubic feet per second at Chicago.

Power development at Niagara Falls and on the St. Lawrence. Both the preservation of the scenic beauty of Niagara Falls and the development of water power there and on the St. Lawrence River have been urged as reasons for refusing to permit a diversion of 10,000 second-feet at Chicago. The controversies on this subject became serious about 1905, when the American Civic Association conducted an aggressive agitation to regulate the use of water for power development at the Falls, on the ground that the beauty of the spot was threatened by such development. Partly because of this agitation Congress passed the so-called Burton bill of June, 1906, limiting the diversion of water from the Niagara River and paved the way for the boundary waters treaty of 1909. That treaty followed

quite closely the recommendations of the International Waterways Commission in a report dated May 3, 1906, which said:

8. The Commission therefore recommends that such diversion, exclusive of water required for domestic use or the service of locks in navigation canals be limited on the Canadian side to 36,000 cubic feet per second and on the United States side to 18,500 cubic feet per second (and, in addition thereto, a diversion for sanitary purposes not to exceed 10,000 cubic feet per second be authorized for the Chicago Drainage Canal), and that a treaty or legislation be had limiting these diversions to the quantities mentioned.

In making the treaty, the Secretary of State afterward testified, it was considered unwise to include any reference to the diversion at Chicago from Lake Michigan because that lake lay wholly within the United States and was not a part of the boundary waters. The treaty forbids any use of the boundary waters "which tends materially to conflict with or restrain any other use which is given preference over it" in this order of precedence:

1. Uses for domestic and sanitary purposes.
2. Uses for navigation, including the service of canals for the purposes of navigation.
3. Uses for power and for irrigation purposes.

The treaty limits the diversion of water from Niagara River above the Falls for power purposes to 36,000 second-feet on the Canadian side and 20,000 second-feet on the United States side.

The International Joint Commission was established by the treaty as a tribunal having final jurisdiction over any case of use, obstruction or diversion of the boundary waters authorized by either Canada or the United States under the terms of the treaty. It has not been asked to report on power development at Niagara but in 1922 it reported on such development on the St. Lawrence and the improvement of navigation on that stream. It then advised further engineering study of the subject, which is now being made by a joint engineering board.

The Engineering Board of Review reported on January 23, 1925, that the restoration of the scenic beauty of Niagara Falls to that of thirty years ago can be accomplished by the regulating works for the control of lake levels. The power possibilities along the Niagara and St. Lawrence River, the Board said, will be increased more by regulating the flow of the Great Lakes than by cutting off the Chicago diversion.

Lake Carriers Association. The most active, consistent opposition to the diversion at Chicago has come from the Lake Carriers Association. Its members are owners and operators of ships on the Great Lakes, and its legal representatives have neglected no opportunity to minimize the flow from Lake Michigan through the Chicago and Calumet Rivers and the drainage canal system. For several years various causes have combined to keep the lake levels unusually low. At the St. Clair River the lowering was about 31 inches below normal at the beginning of this year, but only 5 inches of that depression was due to the diversion at Chicago, the Engineering Board of Review reported. Nevertheless, as each loss of 1 inch in draft is claimed to cost the owners of the lake bulk freighters over $500,000 a year, it is evident why the Lake Carriers Association has been opposing the Sanitary District, all other conditions resulting in a depression of the lake levels being the result of natural causes or legalized operations beyond the influence of the shipping interests.

CHICAGO'S WATER SUPPLY

The water supply of the City of Chicago and most of the other cities and towns in the Sanitary District is necessarily obtained from Lake Michigan. The water is drawn through six intake cribs 2 to 4 miles from the shore into tunnels leading to four pumping stations on the lake front and six stations 2 to 7 miles inland. The chlorination of part of the water supply was begun in 1912 and in 1917 the whole supply was first chlorinated, the practice being carried on since then.

About twenty-five years ago, John Ericson made investigations which convinced him that more than half the water pumped into the Chicago mains was wasted. He sought repeatedly, but unsuccessfully, to have this condition corrected by universal metering. Eventually some relief was obtained through pitometer surveys, house inspections where serious waste was considered probable, and the reduction of pump slip and underground leakage. Nevertheless the per capita consumption has steadily increased to the present excessive quantity, 280 gallons daily.

In addition to supplying residents of the city, the Chicago water department has been required, under the terms of the Sanitary District act, to furnish water to 26 towns and cities outside the city but in the District. An average of 22,000,000 gallons daily, about 100 gallons per capita, were supplied to these communities

TABLE 3

Chicago water supply conditions today and in 1960 under present metering plan and under universal metering plan

The 1960 population is estimated at 7,000,000 but figures are also given for a 1960 population of 5,000,000 (John Ericson).

	YEAR				
	1925	1960			
Population	3,000,000	7,000,000		5,000,000	
Method of controlling water waste	Present metering plan	Present metering plan	Universal metering plan	Present metering plan	Universal metering plan
Commercial and industrial uses:					
Million gallons daily	165	427	427	305	305
Gallons per capita daily	55	61	61	61	61
Domestic use, unmetered:					
Million gallons daily	120	315		225	
Gallons per capita daily	40	45		45	
Public, religious, educational and charitable uses; free:					
Million gallons daily	30	70	70	50	50
Gallons per capita daily	10	10	10	10	10
Underground leakage, slip of meters, etc.:					
Million gallons daily	84	196	56	140	40
Gallons per capita daily	28	28	8	28	8
Park and boulevard use; free:					
Million gallons daily	18	42	42	30	30
Gallons per capita daily	6	6	6	6	6
Plumbing leakage, wilful and unavoidable waste:					
Million gallons daily	364	1820		1300	
Gallons per capita daily	121	260		260	
Total daily pumpage:					
Million gallons daily	840	3080	1120	2220	800
Gallons per capita	280	440	160	440	160
Total annual revenue, million dollars		712	555	557	452
Total annual expenses, million dollars		790	404	624	321
Annual loss, million dollars		78		67	
Annual profit, million dollars			151		131

in 1924, Mr. Ericson stated in a paper recently read before the Western Society of Engineers.

The present water supply was characterized as follows by the Engineering Board of Review:

Under existing conditions it is impossible to meet satisfactorily the hourly variations of water consumption, because of the inertia and slow movement of the water in the long tunnels. A decided lowering of the pressure in the street mains, serious from the fire-fighting viewpoint and annoying to water consumers in some sections, occurs during periods of heavy consumption. Occasionally the pressure in some of the street mains is so low as to affect the reliability of the automatic sprinkling systems in the buildings supplied from these mains.

With the water consumption reduced at once to about 150 gallons per capita daily, it is estimated that there would result a saving of $5,000,000 in the cost of construction of the proposed sewage treatment plants and in the enlargement of existing plants.

Mr. Ericson estimated in his recent paper that by universal metering the daily per capita consumption can be reduced to 160 gallons. Table 3, condensed from his paper, gives his figures of the present condition of the water works and that in 1960, with and without universal metering.

The refusal of the city authorities to adopt extensive metering measures has heretofore made it impossible financially to construct water purification plants, Mr. Ericson stated, "owing to the staggering capacities required on account of the reckless and steadily increasing waste and leakage in the water supply system."

PRESENT CONDITIONS

Although for many years Congress has been asked to consider the problems due to the diversion of water at Chicago, it has taken no comprehensive steps in that direction. The decision of the United States Supreme Court on January 5, 1925, left the matter in the hands of the Secretary of War, under the indefinite authority given to him by the rivers and habors act of 1899 and the references in the treaty of 1909 to the relative importance of different uses of the boundary waters. The latest permit, issued March 3, 1925, reads as follows:

This is to certify that, upon the recommendation of the Chief of Engineers, the Secretary of War hereby authorizes the Sanitary District of Chicago to divert from Lake Michigan, through its main drainage canal and auxiliary channels, an amount of water not to exceed an annual average of 8500 cubic feet per second, the instantaneous maximum not to exceed 11,000 cubic feet per second, upon the following conditions:

1. That there shall be no unreasonable interference with navigation by the work herein authorized.

2. That if inspections or any other operations by the United States are necessary in the interests of navigation, all expenses connected therewith shall be borne by the permittee.

3. That no attempt shall be made by the permittee or the owner to forbid the full and free use by the public of any navigable waters of the United States.

4. That the Sanitary District of Chicago shall carry out a program of sewage treatment by artificial processes which will provide the equivalent of the complete (100 per cent) treatment of the sewage of a human population of at least 1,200,000 before the expiration of the permit.

5. That the Sanitary District shall pay its share of the cost of regulating or compensating works to restore the levels or compensate for the lowering of the Great Lakes system, if and when constructed and post a guarantee in the way of a bond or certified check in the amount of $1,000,000 as an evidence of its good faith in this matter.

6. That the Sanitary District shall submit for the approval of the Chief of Engineers and the Secretary of War plans for controlling works to prevent the discharge of the Chicago River into Lake Michigan in times of heavy storms. These works shall be constructed in accordance with the approved plans and shall be completed and ready for operation by July 1, 1929.

7. That the execution of the sewage treatment program and the diversion of water from Lake Michigan shall be under the supervision of the United States District Engineer at Chicago, and the diversion of water from Lake Michigan shall be under his direct control in times of flood on the Illinois and Des Plaines Rivers.

8. That if, within six months after the issuance of this permit, the City of Chicago does not adopt a program for metering at least 90 per cent of its water service and provide for the execution of said program at the average rate of 10 per cent per annum thereafter, this permit may be revoked without notice.

9. That if, in the judgment of the Chief of Engineers and the Secretary of War, sufficient progress has not been made by the end of each calendar year in the program of sewage treatment prescribed herein so as to insure full compliance with the provisions of condition 4, this permit may be revoked without notice.

10. That this permit is revocable at the will of the Secretary of War, and is subject to such action as may be taken by Congress.

11. That this permit, if not previously revoked or specifically extended, shall cease and be null and void on December 31, 1929.

This permit gives to Chicago for five years all the privileges and authority it has asked, except that of diverting 12,000 second-feet, a request which has practically been withdrawn. A diversion from Lake Michigan of 8500 second-feet coupled with the sewage and surface water entering the Chicago River, the Calumet-Sag Channel and the Main Drainage Channel will yield a flow of 10,000 second-

feet at Lockport. The sixth condition, the construction of controlling works at the mouth of the Chicago River, requires the execution of a project carefully considered by the Engineering Board of Review and rejected because of the probable heavy damages to property owners caused by the operation of such works, since they seem certain to cause backflow in many miles of large sewers.

This permit reinforces the inference drawn from the decision of the Supreme Court that the course followed by the Sanitary District has been free from the charged theft of water and defiance of law of which so much has been said. It is inconceivable that Secretary Weeks, a graduate of the United States Naval Academy and imbued with the Navy's traditions of honorable service, later a distinguished banker, a representative of Massachusetts in the United States House of Representatives for five terms and afterward Senator, would grant the petition of the Sanitary District had it acted as flagrantly as asserted by some critics.

CONCLUSION

The recently granted permit to continue the operation of the Chicago Drainage Canal system is in no sense a permanent settlement of the questions arising from the diversion of water at the south end of Lake Michigan. In what has been said only incidental mention has been made of the value of a Lake-to-Mississippi waterway, now being investigated by a Special Senate Committee, or about the St. Lawrence waterway improvements strongly endorsed by President Coolidge and being studied by an international engineering board. These two propositions are inextricably interwoven with that of the Drainage Canal, but they need not be taken up in this review of the water supply situation, which is complicated enough, in itself.

No permanently satisfactory solution of the sanitation problems of the region will be reached which is restricted to the Illinois shore of Lake Michigan, for the Indiana shore is in much the same condition. Beginning with the Winnetka water intake at the north and going south along the shore there are the Evanston intake and the six Chicago intakes in Illinois and then the Indiana intakes for supplying water to Hammond, Whiting, East Chicago and Gary. These places are rapidly growing into one great community to which the intersecting state boundaryline will mean as little as it does at

Bristol, Texarkana and Winston-Salem. They all must get their water from Lake Michigan, and the overwhelming preponderance of engineering opinion is that their sewage must be kept out of Lake Michigan, preferably by discharging it into the Calumet River which will deliver it through the Calumet-Sag Channel to the Main Drainage Canal.

TABLE 4

Typhoid fever death rates in Chicago and neighboring cities in Indiana

YEAR	GARY	EAST CHICAGO	WHITING	HAMMOND	CHICAGO	MICHIGAN CITY
1900					20.0	
1901				91.0	29.0	
1902				64.0	45.0	
1903				121.0	32.0	
1904				38.0	20.0	
1905				61.0	17.0	
1906				56.0	19.0	
1907				80.0	18.0	
1908				154.0	16.0	
1909				39.0	13.0	
1910	101.0	26.0	60.0	57.0	14.0	
1911	24.0	29.0	43.0	37.0	11.0	
1912	0.0	40.0	28.0	70.0	7.6*	
1913	0.0	46.0	27.0	64.0	11.0	
1914	0.0	12.0	12.0	49.0	6.9	
1915	6.0†	11.0	13.0†	36.0	5.3	14.5
1916	83.0	38.0	75.0	122.0	5.1	33.1
1917	23.0	43.0	62.0	96.0	1.6	44.4
1918	11.0	37.0	25.0	54.0†	1.4	
1919	31.0	72.0	24.0	51.0	1.2	
1920	10.0	25.0‡	29.0‡	41.7	1.1	5.1
1921	7.2	25.0	9.9	22.2	1.2	10.2
1922	7.2	§	19.7	8.4	1.1	
1923	1.8	5.8	§	19.4	1.9	5.1

* Chlorination began in January.
† Chlorination began.
‡ Filter plant installed.
§ No record.

The only perceptible currents in the south end of Lake Michigan are those due to winds and barometric changes. The continued discharge of sewage and industrial wastes into this source of water supply of what seems destined to be the largest community on the continent is a matter of national sanitary concern. The chief

facts regarding the quality of the water supplies of Chicago and the Indiana cities, as revealed by the typhoid fever mortality rates, were recently compiled in table 4 by L. A. Geupel, then director of the Water and Sewage Division, Indiana State Board of Health. His opinion of the situation was stated as follows on May 14, 1924, at a hearing by the Rivers and Harbors Committee of the United States House of Representatives:

With our knowledge of the past we know that the diversion from the lake through the Sanitary District Drainage Canal and the Calumet-Sag Canal of all liquid wastes is the best method of maintaining satisfactory water supplies and generally good healthy conditions in South Chicago, Hammond, East Chicago and Whiting.

The sanitary situation of this great community is just now in a quiescent state, so far as public attention to it is concerned. All parties to the controversies claim to be satisfied with the terms of the permit issued by the Secretary of War. Actually, they have been successful to this extent, that they have shown there is merit in their respective contentions and their claims have had more or less recognition in the permit and the documents issued with it. However, the investigations now being made by authority of Congress will bring the subject up for discussion again before long.

Plainly, where so many important interests are involved, governmental, economic, transportation, sanitary and engineering, no one professional or other group can justly claim to be able of itself to determine the right course to follow. Furthermore the States of Illinois and Indiana are keenly interested for sanitary reasons, and the former State on account of the Illinois Waterway as well, and consequently no exclusively national control will ever be entirely acceptable from the viewpoint of those States.

At the present time there is no form of commission by which all the interests involved can be represented officially by delegates around a council table to compromise their claims. It is a new kind of interurban, interstate and international problem, where each party has rights and none can get all it now claims without injustice to the rights of others. In great business affairs, such a condition formerly led to fighting and wreckage, but business has learned that compromise is better than fighting.

In a paper recently presented before the Western Society of Engineers, George W. Fuller said that the best method of finding a way to a permanent solution of the problem, flexible enough to

meet the changes in conditions certain to come with greater knowledge of water and sewage treatment, improvements in power development and in shipping, and wider experience in the control of lake levels and the operation of inland waterways, would be for the President to ask all parties to send delegates to a conference to determine those points upon which two or more of them agreed and to define clearly the points upon which there was disagreement and the reasons for the diverse opinions. Such a conference could pave the way for creative study by a Congressional committee which, it is reasonable to hope, will result in legislation as helpful to the Great Lakes region as the Federal Reserve Act and the Farm Loan Act have been to commercial and agricultural interests. Those laws were novel, basic and broad, and the same kind of law is needed to solve the conflict of interests arising from diversions of water from the Great Lakes.

ABSTRACTS OF WATER WORKS LITERATURE

Frank Hannan

Key: American Journal of Public Health, 12: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

Stopping Water Leaks in Dayton, Ohio. Anon. Amer. City, 31: 106, 1924. Pitometer survey lasting about a year disclosed 400 leaks, amounting to 3.25 m.g.d. Daily pumpage reduced 8 per cent below previous year.—*W. Donaldson.*

Sanitation on the Catskill Water Shed. Thaddeus Merriman, Amer. City, 31: 119–120, 1924. (From paper before annual convention of A. W. W. A.).—*W. Donaldson.*

Specification for Cast Iron Pipe. Anon. Amer. City, 21: 159–160. Preliminary steps taken by American Engineering Standards Committee regarding this material. Joint sponsorship designated to Amer. Gas. Assn., Amer. Water Works Assn., and Amer. Soc. for Testing Materials.—*W. Donaldson.*

New Venturi Effluent Controllers at Detroit. Ed. S. Smith, Jr., and Charles G. Richardson,. Amer. City, 31: 171–2, 1924. Illustrated description of devices used on the 80 filter units at Detroit; flow integration is special feature.—*W. Donaldson.*

Planning the Financial Program for the New Water Works in the Small Town. Richard Messer. Amer. City, 31: 187–192, 1924. Timely and valuable advice to small communities contemplating water works installation. Four assumed examples are studied to illustrate methods of arriving at probable water consumption, amount of investment, fixed charges, operating expense, and rates to be charged for water service. Principles outlined are applicable to other than the 1500 population assumed in examples.—*W. Donaldson.*

A Study of Filter Sand for Municipal Water-Supplies. W. M. Weigel. Amer. City, 31: 193–195, 1924. General requirements and specification of filter sand are reviewed. New Jersey, North Carolina, Illinois, Minnesota and Missouri named as chief producing sections, sources being ocean beaches, lake deposits, river bars, sand banks, and soft sandstone. Method of mining, handling, and sizing are outlined. Prices range $4 to $8 per ton in car load, f.o.b. shipping point; $10 to $12 per ton in bags in less than car lots.—*W. Donaldson.*

A Unique Method of Cleaning Filter Sand. C. H. Capen. Amer. City, 31: 215–217, 1924. Rapid sand filters of Salem, N. J., Water Works became clogged, due to character of applied water and improper washing method. Sand was cleaned in place by Little Falls method of steeping with caustic soda and soda ash. For filter units of 190 square feet area, there were used 175 pounds caustic soda and 250–300 pounds soda ash. Steam connected to filter manifold and to special grid over troughs supplied heat. Required 12 hours to bring temperature to 175°F. where it was held for 40 hours. Finally washed in customary way with water. Air agitation was tried on one filter. Author believes chemical method is cheaper and easier than mechanical methods and as effective.—*W. Donaldson.*

Maintenance of Oil Circuit Breaker Operating Mechanisms. H. L. Biggin. Power, 60: 19, 721, November 4, 1924. Operation and care of oil circuit breaker mechanisms are discussed.—*A. G. Nolte.*

Ice Problems at Hydro-Electric Plants. Power, 60: 19, 743, November 4, 1924. Among suggestions made as to how ice may be prevented from interfering with plant operation, are included:—heating of affected parts to 0.001°F. above freezing; electrically heated racks; discharging low pressure compressed air near bottom of forebay; formation of slack water pools; housing and heating head works by steam or electrically. Where applicable, use of compressed air seems to be the most economical in practice.—*A. G. Nolte.*

Maintenance of Wood-Stave Pipe in Hydro-Electric Practice. B. E. White. Power, 60: 21, 794, November 18, 1924. Information relative to proper methods of installation and maintenance of wood-stave pipe for water conduits, including description of cases where trouble has developed.—*Aug. G. Nolte.*

Maintenance of Oil Circuit Breakers—Contacts and Oil. H. L. Biggin. Power, 60: 21, 797, November 18, 1924. Care and maintenance of oil circuit breakers is discussed. Items considered are, inspection and adjustment of contacts; care of connections and bushings; care required in removing and replacing oil tanks; sampling and testing of oil.—*Aug. G. Nolte.*

Reconstruction of Oshkosh Water-Works. J. S. Harth. Power, 60: 21, 802, November 18, 1924. Old steam pumping plant was electrified by installing Synchronous-Motor-Gasoline Engine Pumping Units. To insure continuity of electric service for low head pumps, arrangements were made so that one motor in pumping plant could be run as generator by driving it through one of the 2500 gallon pumps with gasoline engine.—*Aug. G. Nolte.*

Preventing Corrosion with Water Glass. Power, 60: 21, 824, November 18, 1924. Silicate of soda now being used to protect pipes from corrosion. When either liquid or solid form is added to water passing through pipe, protective film is gradually built up on inside of pipe, which greatly reduces corrosion. Several proprietary compounds containing silicate of soda are

now on market. Chief application to date has been domestic water lines. Addition of silicate of soda to cold water reduces corrosion about 50 per cent (according to tests made in Cambridge, Mass.); in hot water, film was built up in thirty days which gave reduction in corrosion amounting to 80 per cent. —*Aug. G. Nolte.*

Special Applications of Standard Transformers. J. B. Gibbs. Power, 60: 22, 841, November 25, 1924. Emergencies may arise where transformer is to be operated under other than rated conditions. Whether or not transformer will stand up to the service depends on losses in the transformer and on its insulation. Author discusses various phases of this problem.—*Aug. G. Nolte.*

Fairmount Pumping Station and Heating Plant. L. A. Quayle. Power, 60: 22, 844, November, 1924. General description of Cleveland's new plant. Station has six functions to perform, in supplying water and steam to the community and alternating-current to pumping station and filtration plant buildings.—*Aug. G. Nolte.*

Hazards of Pulverized-Fuel Systems. H. E. Newell and R. Palm. Power, 60: 22, 847, November 25, 1924. Under certain conditions pulverized fuel, outside of combustion chamber, may give rise to flash fire, dust explosion, or, possibly, spontaneous ignition. Authors present number of installation features that minimize fire hazard and go far toward safe-guarding life as well. Safety features of various types of pulverized-fuel systems are discussed.—*Aug. G. Nolte.*

Analyses of Boiler Compounds. Power, 60: 22, 859, November 25, 1924. Abstracted from Serial Report of N. E. L. A. Prime Mover's Committee. Analyses of some fifteen so-called "boiler compounds" or "boiler metal treatments" now on market are given as well as comparison on basis of percentage of sodium oxide.—*Aug. G. Nolte.*

Air Preheaters and Their Application. Power, 60: 23, 885, December 2, 1924. Comparatively few plants are now utilizing air preheaters; many more have either ordered units of this character or are considering their installation, both in connection with and without economizers. Preheaters represent from one-half to twice the boiler heating surface and are at present limited in temperature of heated air to about 450°F. In addition to gains due to recovery of heat from stack gases secondary gain is ordinarily realized due to better combustion. Preheating is particularly adapted to furnaces where water or air-cooled surfaces readily absorb radiant heat. Other interesting sidelights on preheating of air are noted and discussed and several types of preheaters and their principles of construction are illustrated.—*Aug. G. Nolte.*

Preheating Fuel Oil for Diesel Engines. R. A. Melrose. Power, 60: 23, 904, December 2, 1924. Fuel oils having low Baumé reading become

viscous at low temperatures and often give trouble due to tendency to solidify, thus choking fuel pump and pipe. Steam, electricity, and exhaust gases from engine have been utilized to develope preheating systems to insure free flowing oil. Steam coils have been largely used with success; continuous coils recommended to minimize danger of leaking joints. Electricity is rather a doubtful medium for fuel-heating purposes on account of deterioration of coil system, especially with trace of acid in the fuel. Preheating by means of exhaust gases from engine through connection tapped from main exhaust pipe is common and generally satisfactory; disadvantage is that carbon is likely to accumulate. In all cases service tank had better be well above level of fuel pump.—*Aug. G. Nolte.*

Measuring Condenser Leakage with a Megger. H. Edwards. Power, **60**: 23, 907, December 2, 1924. Method for determining leakage of condensers, using cooling water of low conductivity, is fully illustrated and described. —*Aug. G. Nolte.*

Brush Angle and Direction of Commutator Relation. W. C. Kalb. Power, **60**: 25, 973, December 16, 1924. Theoretical and practical discussion of leading and trailing positions of brushes. Concluded that if brush holder is designed primarily for rotation of commutator away from sharp edge of brush face and can be adjusted to an inclination of approximately 15 degrees from the radial but not greater than 25 degrees, trailing operation is preferable; but if holder design is suitable and permits inclination of 30 degrees to 37.5 degrees from the radial, rotation of commutator against sharp angle of the brush face is generally preferable.—*Aug. G. Nolte.*

Boiler Feed Pump Explanations and Calculations. C. L. Hubbard. Power, **60**: 25, 979, December 16, 1924. Fundamental principles of suction lift are illustrated and explained from theoretical and practical standpoints. Variations in temperature of water pumped and pressure pumped against are considered. Practical example of boiler feed pump performance is assumed and calculations made.—*Aug. G. Nolte.*

High Bridge Steam Plant at St. Paul. Power, **60**: 26, 1006, December 23, 1924. Present installation consists of two 30000 kw. units, each served by four boilers; as future units will be of same size or larger, final generating capacity of at least 240000 kw. is expected. Following out general plan of economy of production with minimum investment, there is little duplication of equipment even in auxillaries. Underfeed stokers were preferred to pulverized fuel. Only extravagances in entire station were stage heaters and evaporators to supply pure water for boiler makeup. General arrangement of station is illustrated, and operation of some of principal equipment, described.—*Aug. G. Nolte.*

Selecting Boiler Feed Pumps. C. L. Hubbard. Power, **60**: 26, 1021, December 23, 1924. Direct-acting steam pump has been widely used in plants of small and medium size. Duplex type is preferable to simplex, on

account of continuous flow. Advantages of direct-acting steam pump for boiler feeding are low first cost, simplicity, low maintenance, and ease of speed regulation. Principal disadvantage is large steam consumption which varies from 100 to 200 pounds per indicated horsepower per hour according to size and speed. Centrifugal pumps are in general use for boiler feeding in plants of 500 horsepower and over; they are almost universally employed in those of 1000 to 1500 horsepower and above. Advantages of this type of pump are simplicity, absence of valves, and continuity of delivery. Principal disadvantage is difficulty of securing proper regulation at constant speed without interfering with pressure characteristics and efficiency. Combination of motor-driven pumps for steady load and turbine-driven units for variable, works out quite satisfactorily. Author further discusses bearing of above characteristics of different types of pumps upon selection of outfit for various locations and conditions of operation.—*Aug. G. Nolte.*

Operation of Electrical Temperature Indicators and Recorders. E. H. Stivender. Power, 60: 27, 1051, December 30, 1924. Operation of various methods that have been devised and used commercially for measuring temperatures electrically are briefly described and illustrated.—*Aug. G. Nolte.*

Why Turbine-Driven Pumps Were Selected for Fairmount Station. L. A. Quayle. Power, 60: 27, 1057, December 30, 1924. Article is abstract of address delivered at spring meeting of A. S. M. E. Study is made of factors determining selection of prime movers for Cleveland pumping units.—*Aug. G. Nolte.*

Some Specific Factors Responsible for Pollution or Affecting Analyses of Water Supplies. Public Health Reports, 39: 45, 2788, November 7, 1924. Summary of factors responsible for pollution of water supplies at various stages of the supplying, purifying, and distributing processes. Contributing factors are listed under following general headings;—Source of supply; Treatment; Pumping Equipment; Storage; Distribution; and Operation. Of particular interest to persons engaged in sanitary supervision of water supplies.—*Aug. G. Nolte.*

Questions and Answers. Franklin Van Winkle. Power. Questions are asked and answers given on following subjects—60: 19, 738, November 4, 1924. Temporary forcing of Water Tube Boilers; Calibrating Steam Consumption; Conversion of Metered Volume of Gas to Volume at a Standard Pressure; Required Diameter of Water Cylinder of Duplex Pump; Utilizing Exhaust Steam for Heating; Eccentric Equivalent to Crank. 60: 20, 778, November 11, 1924. Rocking Valve; Saving from Use of Economizer; Preventing Corrosion of Copper. 60: 21, 818, November 18, 1924. Water Column Connections; Testing Motor Field Coils; Napier's Formula for Flow of Steam; Repair of Pitted Spot in Boiler Shell; Air Supply per Ton of Coal Burned; Butt and Double-Strap Joint, Double Riveted; Reduction of Baumé Reading to Pounds of Oil per Gallon. 60: 22, 856, November 25, 1924. Flooding of Low-Pressure Radiator; Effect of Wear on Turning Down Crankpin

or Crosshead Pin; Saving from Returning Condensate to Boiler; Corrosion of Boilers; Horsepower of Adjustable-Speed Shunt Motor; Steam Discharged Through Header; Knocking of Pump After Equalizing Lost Motion; Prevention of Corrosion of Smoke Flues. **60**: 23, 912, December 2, 1924. Size of Connection for Heating Unit; Galvanizing Cast Iron; Greater Speed Required for Feed Pump; Quality of Steam from Steam Tables; Unequal Lap of Valve of Single-Valve Engine; Setting Valves of Double-Eccentric Corlis Engine; Measuring Velocity of Water With Pitot Tube. **60**: 24, 956, December 9, 1924. Balanced Valve with Pressure Plate; Boiling Out a Boiler; Percentage of Tank Capacity Discharged for Stated Reduction of Air Pressure; Frequency of Blowing Down Boiler; Providing Supplemental Exhaust When Required for Heating. **60**: 25, 992, December 16, 1924. Cleaning Water Leg of Vertical Boiler; Steam Required to Heat Fuel Oil; Air Pressure for Air Life; Pitting of Horizontal Return-Tubular Boiler Over Fire; Resetting Valves of Buckeye Engine; Determining Safe Working Pressure for Boiler; Content of Tank; Resistance of Cylindrical Shells to Collapsing Pressure. **60**: 26, 1032, December 23, 1924. Double Riveted Girth Seams; Importance of Counterbore for Engine Cylinder; Equivalence of Gauge Readings at Different Altitudes; Equivalent Evaporation; Overheating of Air Compressor. **60**: 27, 1076, December 30, 1924. Advantages of Center-Crank Engine; Overheating of Air Compressor; Piston Travel Clearance; The Pressure of Natural Draft is Greater at Sea Level; Temperature and Work from Adiabatic Compression of Air; Steam accounted for by Indicator Diagram; Water Discharged by Pipe Line with Gate Valve Wide Open.—*Aug. G. Nolte.*

Algae in Public Water Supplies. W. C. PURDY. Eng. News Rec., **94**: 103, 1925. Reagents for combating algal growths include $CuSO_4$, Cl, lime, and H_2SO_4. Removal of CO_2, which is utilized as food by algae, with lime was suggested by Houston. Sulphuric acid, when used, is added in sufficient amount to neutralize all bicarbonates, removing this source of CO_2. Algae aid in self-purification of water by producing O_2 by photosynthesis. Examination of Illinois river water over period of 14 months showed a plant content of 65–95 per cent of total plankton.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Supreme Court Restricts Chicago Drainage Diversion. Eng. News Rec., **94**: 110–2, 1925. Text of unanimous decision written by Justice Holmes, handed down January 5, 1925, affirming lower court injunction restricting Chicago river flow to 4167 second-feet.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Water Supply and Sewage Disposal in the Ruhr Valley. KARL IMHOFF. Eng. News Rec., **94**: 104–6, 1925. Daily average of 250 million gallons is drawn through 90 water works from Ruhr river, by means of wells and infiltration galleries 150 feet from river, to supply 3½ million inhabitants of district. Difficulties due to sludge deposits on river bed, preventing penetration of the water, have been overcome by construction of filter basins supplied

with river water. Two basins are operated alternately to avoid interruption of supply during cleaning of layer of sand provided at bottom of each basin. Purification effected is very high and water is fit for immediate consumption, except at time of very high or very low water, when chlorination is resorted to. Impounding reservoirs have been constructed by Ruhr-Talsperren Verein (amalgamation of water works of district) to augment low flow. Discharge of sewage and industrial wastes into river is controlled by "Ruhr Verband."—*R. E. Thompson.*

The Colorado River. Eng. News Rec., **94**: 57–63, 1925. Colorado river discussed regarding irrigation and power possibilities, flood control, and international and interstate relationships. Suspended matter content is very high, river being classed as one of muddiest of world. Salt content is 200–300 p.p.m. during floods, and 1200 and higher during 8 non-flood months. Denver draws water from this source for municipal purposes, and claims have been advanced by Los Angeles and San Diego.—*R. E. Thompson.*

New Steam Valve. Anon. Chem.-Ztg., **46**: 898–9, 1922. From Chem. Abst., **17**: 230, January 20, 1923. Valve is opened with wheel, like gate valve, but movable part is cylindrical plug, and seal is effected by special packing rings made of elastic material instead of contact of two metal surfaces. Leakage is less, life is longer, and repairs are more easily made than with ordinary valve.—*R. E. Thompson.*

Belt Conveyor Handles Cement for Large Aqueduct. Eng. News Rec., **64**: 149–51, 1925. Methods of form handling and concrete placing employed in construction of second section of large covered aqueduct to control Scajaquada Creek, Buffalo, N. Y., are outlined.—*R. E. Thompson.*

Technical Sedimentation Analysis. I. Friedrich-Vincenz v. Hahn and Dorothea v. Hahn. Kolloid-Z., **31**: 96–101, 1922. From Chem. Abst., **17**: 246, January 20, 1923. Size and form of apparatus previously described (cf. Ostwald and Hahn, C. A. **16**: 3773) were modified and made suitable for use in technical analyses.—*R. E. Thompson.*

The Use of Conductivity Titrations in Precipitation Analyses. V. Conductivity Titrations with Barium Salt. I. M. Kolthoff. Z. anal. Chem., **61**: 433–8, 1922. From Chem. Abst., **17**: 247, January 20, 1923. Data on titrations with barium salt given. Conductivity method cannot be used for sulfates in drinking water as calcium causes low results, the disturbance being serious in dilute solutions.—*R. E. Thompson.*

Determination of Available Chlorine in Chlorine Bleaching Compounds. F. Dienert and F. Wandenbulcke. Ann. fals., **15**: 338–9, 1922. From Chem. Abst., **17**: 251, January 20, 1923. Dilute 1 cc. of bleaching solution to 1 liter, add 2 grams ammonium sulfate, shake, add few crystals of potassium iodide and starch solution, and titrate liberated iodine with alkaline arsenious acid. The ammonium sulfate prevents formation of iodate. Method

was compared with those of Penot, Gay-Lussac, and Poncious, all giving approximately equal results. Latter method gave consistently higher figures, particularly with low chlorine contents, error depending on rate of addition of potassium iodide solution, as reaction between potassium iodide and iodate is not instantaneous. Penot's method is not suitable for very dilute solutions.—*R. E. Thompson.*

A Micro-Winkler Method for the Quantitative Determinations of Dissolved Oxygen. E. J. LUND. Proc. Soc. Exptl. Biol. Med., **19:** 63–4, 1921. From Chem. Abst., **17:** 293, January 20, 1923. Winkler method is applied to 10, or even 5 cc., by adding 0.1 cc. of manganese chloride and of alkaline iodide solution and titrating in tall dish, using 5 cc. buret and thiosulfate of $\frac{1}{10}$ usual concentration. End point is as definite and error same as with ordinary procedure, maximum error being less than 0.005 cc. oxygen.—*R. E. Thompson.*

Flash Evaporator Furnishes Pure Make-Up Water to Boiler. ANON. Power Plant Eng., **26:** 1078–9, 1922. From Chem. Abst., **17:** 320, January 20, 1923. Raw water is heated under pressure in tubular heater to point below which impurities are deposited as scale, and pumped into vacuum evaporator where it is immediately flashed into steam. Distillate is practically pure water, claimed to be free from dissolved and entrained oxygen.—*R. E. Thompson.*

Distilled Water for Boiler Feed. ANON. Power Plant Eng., **26:** 1013–4, 1922. From Chem. Abst., **17:** 320, January 20, 1923. Multiple heating effects recommended for production of distilled water for boiler feed. –*R. E. Thompson.*

De-Aërating Heater Reduced Tube Corrosion. ANON. Power Plant Eng., **26:** 1068, 1922. From Chem. Abst., **17:** 320, January 20, 1923. Water to be de-aërated is sprayed over trays and falls into storage pool in vacuum heater. Steam used for heating water is introduced through perforated manifold at bottom of storage space, carries out dissolved gases, and is withdrawn by air pump. Vacuum maintained depends upon final temperature to which water is heated.—*R. E. Thompson.*

Report of the Institute of Hygiene of Water on the Salt Content of the Weser at Bremen. K. THUMEN. Mitt. Landesanstalt Wasserhyg., **26:** 1921; Gesundh. Ing., **128:** (March 11, 1922); German Office Intern. Hyg. Publ., **14:** 981, 1922; Pub. Health Eng. Absts., December 9, 1922. From Chem. Abst., **17:** 321, January 20, 1923. Permissible limits for chlorine content of water supplies discussed. Former commission stated "an increase in chlorine content of Weser water to 350 p.p.m. at Bremen would not cause objection from a hygienic standpoint," while National Inst. of Water Hyg. had already fixed maximum at 170 p.p.m. Chlorine content of 143 p.p.m. was judged "normal" by taste, but 190 p.p.m. had salty or bitter taste. Allowance of 350 p.p.m. is protested against.—*R. E. Thompson.*

The Occurrence of Sulphate Reduction in Lower Soil Strata. C. A. H. von Wolzogen Kühr. Verslag Akad. Wetenschappen Amsterdam, **31:** 108–18, 1922. From Chem. Abst., **16:** 3999, November 20, 1922. Soil samples taken from wells at varying depths showed decrease of aërobic and increase of anaërobic bacteria with increasing depth. Sulphate reduction, shown by presence of iron sulphide, began at depth of approximately 10 m. and continued to 37 m., the greatest depth studied. Both the anaërobes and aërobes isolated produced acid from glucose, Prussian blue from $FeFe(CN)_6$, hydrogen sulphide from beef bouillon, and the enzymes emulsin, lipase and amylase. No spores were formed. The anaërobes reduced nitrate to nitrite and liquefied gelatin, while the aërobes did not. Only one species of aërobe grew in absence of air, while all the anaërobes grew luxuriantly with access of air. The bacteria isolated are considered for the most part faculative anaërobes.—*R. E. Thompson.*

The Ionometer. A Simple Clinical Method for Conductivity Determinations. Johanne Christiansen. Wiener klin. Wochschr., **35:** 461–2, 1922. From Chem. Abst., **16:** 4231, December 10, 1922. Apparatus, suitable for conductivity determinations of water, described.—*R. E. Thompson.*

The Bacteriological Study of Drinking Water. J. J. de Waal. Centr. Bakt. Parasitenk., II Abt. **52:** 10–8, 1920; Abst. Bact., **5:** 94. From Chem. Abst., **16:** 4240, December 10, 1922. For demonstration of B. coli, two media are used: (1) acid nutrient bouillon containing 0.5 per cent lactose and 10 mgm. neutral red per 100 cc. of medium; and (2) pegallac, a medium consisting of distilled water with 3 per cent camebile, 1 per cent Witte peptone, 10 per cent lactose and 2.5 per cent litmus solution. –*R. E. Thompson.*

The Relation of Alkaline Waters to the Preparation and Dilution of Sprays and Dips. E. R. de Ong. J. Econ. Entomol., **15:** 339–45, 1922. From Chem. Abst., **16:** 4294, December 10, 1922. Soluble salts in water react with certain insectides and fungicides to form soluble compounds which injure foliage, and also break insectide emulsions. Study of 80 California waters showed that only 14.8 per cent could be safely used with lead arsenate on tender foliage. Basic lead arsenate should be used with hard waters.—*R. E. Thompson.*

The Chemical Attack of Gas Conduits and Gas Apparatus. Wilhelm Bertelsmann. Het Gas, **42:** 142–8, 1922. From Chem. Abst., **16:** 4328, December 10, 1922. When cast iron pipe is laid in clay or gypsum, which exclude the air, local currents flow from the graphite particles to the pure iron, causing anodic corrosion or dissolution. Resulting material, which is spongy and readily cut with knife, contains 24 per cent carbon, 12 per cent silicon, up to 2.7 per cent phosphorus, and 0.4 per cent sulphur; 60 per cent of original iron content having been lost. Presence of carbon dioxide increases dissolution. Cast iron in light sandy soil, allowing free access of air, is not subject to spongy destruction as protecting layer of oxide is formed under these conditions. Tarring pipes affords protection from stray currents by providing insulation.—*R. E. Thompson.*

Water Supply for the Dye Industry. Julius Schmidt. Deut. Färber-Ztg., **58**: 835–6, 1922. From Chem. Abst., **16**: 4351, December 10, 1922. Surface waters must be freed from algae and other suspended matter, and softened if hardness is greater than 8°.—*R. E. Thompson.*

Iron Pigments. O. Bertram. Lack u. Farb. Rundsch. 1921, **9**: 191–6; Chimie et industrie, **8**: 641, 1922. From Chem. Abst. **16**: 4357, December 10, 1922. General review of preparation, properties, and merits of various iron pigments.—*R. E. Thompson.*

Surface Protection by Painting. J. F. Sacher. Z. angew Chem., **35**: 481–3, 1922. From Chem. Abst., **16**: 4357, December 10, 1922. Review of corrosion, protective metallic and chemical coatings, and especially of white lead and red-lead-oil paints. –*R. E. Thompson.*

American Society for Testing Materials Tentative Standards, 1923. 859 pp. 1315 Spruce St., Philadelphia, Pa. From Chem. Abst., **18**: 429–30, February 10, 1924. List of tentative specifications, methods, definitions, and recommended practice.—*R. E. Thompson.*

Simplifying the Solution of Problems of Fluid Flow. B. F. Dodge. Chem. Met. Eng., **29**: 844–6, 1923. From Chem. Abst., **18**: 430, February 10, 1924. Calculation of pressure drop, pipe length, velocity, diameter, capacity, density, and viscosity, employing standard equations (cf. C. A. **16**: 1118) outlined.—*R. E. Thompson.*

Small Feed-Water-Treating Equipment for $100. C. B. Oliver. Elec. World, **82**: 867–8, 1923. From Chem. Abst., **18**: 431, February 10, 1924. Equipment consists of 50-gallon steel barrel, line to boiler-feed pump, and water-testing outfit. Soda ash is fed into line. Boiler water is tested twice daily; quantity of water is blown from boilers periodically, 2–5 times a day; and chemicals are fed regularly in small quantities.—*R. E. Thompson.*

High-Strength Cements. Jean Hendrickx. Chimie et industrie, **8**: 296–304, 1922. From Chem. Abst., **16**: 4038–9, November 20, 1922. Quality of artificial cement depends mainly on its physico-chemical composition, burning and cooling, and fineness of grinding. By use of more calcium oxide than given by maximum of formula there is no great increase in strength, but danger of swelling. With less than the minimum, strength falls off. Examination of thin sections of fused aluminous cement seems to show that this cement is mixture of silicates and aluminates and does not consist of aluminates crystallized in an iron silicate as was at first believed. Two kinds of crystals are distinctly visible under microscope, polarizing and non-polarizing. Latter seem to be more important as regards quick setting and high initial strength. Ratio (specific gravity)/(weight per liter) is called "modulus of fineness" and is used as measure of absolute fineness. Tests of 100 samples showed that the higher the modulus of fineness, the better the quality of cement; that high initial strength cannot normally be obtained

with modulus below 2.6; and that modulus does not have same effect on all cements, thus showing importance of crystalline form.—*R. E. Thompson.*

Re-Using Water Condensate, and Testing its Suitability by Means of an Electric Condensate Tester. CONRAD WINTER. Chem. App., 10: 161-2, 1923. From Chem. Abst., 18: 431, February 10, 1924. Apparatus depends on increased conductivity of water due to entrained salts or leakage.—*R. E. Thompson.*

Chemistry of Combustion Oil and Gas. L. BALLIET. Oil and Gas J., 22: 25, 23, 119, 1923. From Chem. Abst., 18: 456, February 10, 1924. Relative values are given with arbitrary prices for coal, oil, gas and electricity, and heating values of various commercial gases are listed.—*R. E. Thompson.*

Apparatus for Automatic Flue Gas Analysis. C. VRINS. Arch. Suikerind, 31: 1121-7, 1923. From Chem. Abst., 18: 459, February 10, 1924. "Cocoo" apparatus described. "Single" form furnishes record of carbon dioxide, and "double" form carbon dioxide and monoxide. Table given in original showing percentages of carbon dioxide and monoxide and heat losses in chimney, assuming temperature drop of 250°.—*R. E. Thompson.*

Discussion of Heat Balance (in Boiler Tests). A. LINGUET. Chimie et industrie, 10: 829-35, 1923. From Chem. Abst., 18: 459, February 10, 1924. In computing heat balance in boiler tests, it is assumed that flue gas contains no unburned carbon. L. shows that this is frequently not true and gives method of calculating amount of unburned carbon present from analyses of fuel and flue gas. Thermal efficiency of boilers is frequently much lower than that calculated by usual method: 57.5 per cent, instead of 78.5, in one instance discussed.—*R. E. Thompson.*

Purification of Water for Tannery Use. P. HUC. Halle aux Cuirs, 9: 257-63, 1923. From Chem. Abst., 18: 480, February 10, 1924. Review, chiefly of modern methods of softening.—*R. E. Thompson.*

Wood Stave Pipelines at Vancouver are Proved Reliable. Contract Record, 38: 699, 1924. Failure of wood stave pipeline in Vancouver, B. C., reported. Pipe was designed by city engineers and constructed in 1907 of material cut on ground. Failure occurred when additional 25 feet of head was applied, and was due to blowing out of short piece of stave which had become affected with dry rot, a condition explained by fact that working head for number of years was insufficient to maintain full saturation of wood.—*R. E. Thompson.*

A Device for Water Analysis and Slow Filtration. A. C. SIMMONS. Ind. Eng. Chem., 15: 901, 1923. From Chem. Abst., 17: 3114, October 10, 1923. —*R. E. Thompson.*

A Device for Water Analysis and Slow Filtration. A. C. SIMMONS. Ind. Eng. Chem., 15: 1284, 1923. From Chem. Abst., 18: 486, February 20, 1924.

Cf. preceding abstract. Further explanation of principle involved.—*R. E. Thompson.*

A Device for Water Analysis. Charles Van Brunt. Ind. Eng. Chem., **15**: 1284, 1923. Alternative explanation is offered of principle involved in filtration device of Simmons (cf. previous abstracts) and simpler modification is described.—*R. E. Thompson.*

A Revolution in the Power Field. Anon. Chem. Met. Eng., **29**: 1174–5, 1923. From Chem. Abst., **18**: 558, February 20, 1924. Description of the mercury boiler. Success in tests on binary vapor boiler and turbine indicates great future economies in power generation. Experimental plant at Hartford, Conn., illustrated.—*R. E. Thompson.*

Radioactivity of the Parlanti Water and of the Gas of the Grotto (Monsummano). Roberto Salvadori. Ann. chim. applicata., **13**: 151–4, 1923. From Chem. Abst., **18**: 497, February 20, 1924. Data determined with Elster and Geitel fontactoscope by method of Nasini, Marino, Ageno and Polezza (cf. C. A. **7**: 2980).—*R. E. Thompson.*

Measuring Water with Salt and Electricity. C. M. Allen. J. Elec., **52**: 8, 1924. From Chem. Abst., **18**: 500, February 20, 1924. "Salt-velocity" method consists of injecting brine into conduit and accurately measuring time of passage at point further downstream by means of conductivity apparatus. Comparative tests with Venturi meter, weir, and weighing tank show method to be very accurate.—*R. E. Thompson.*

Experiences in the Investigation of Water for Coli Bacteria. Andreas Gaál. Z. Nahr. Genussm., **46**: 37–43, 1923. From Chem. Abst., **18**: 543, February 20, 1924. Sterile and unsterile conductivity water, distilled water, and "bitter water" were inoculated with B. coli from man and held for varying lengths of time at varying temperatures from 10 to 37°. B. coli developed most rapidly at 10°. After 34 days sterile and unsterile "bitter water" and sterile conductivity water still contained B. coli. Results indicated that presence of bacteria other than B. coli in conductivity, distilled, or saline waters tends to inhibit growth of B. coli, particularly at higher temperatures. —*R. E. Thompson.*

NEW BOOK

Grundzüuge der Hygiene. C. Prausnitz and W. Prausnitz. Munich: J. F. Lehmann. 12th edition. M. 17. Reviewed in Gesundh. Ing., **46**: 221, 1923. From Chem. Abst., **18**: 562, February 20, 1924.—*R. E. Thompson.*